DEVOTED TO THE SCIENCE AND ART OF ILLUMINATION

THE ILLUMINATING ENGINEER

EDITED BY LEO J. GASTER.

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EDITORIAL.

THE recent important developments in our methods of producing light, and the growing interest taken in the subject of proper illumination, have convinced us of the necessity of issuing a special Magazine, devoted solely to the careful study and consideration of all aspects of the subject. Due attention will be paid to the requirements of the consumer and professionals by keeping them in touch with the most recent results obtained.

Apart from the inefficient nature of our present methods of converting electrical or any other variety of energy into light, a very large amount of the light actually produced is unnecessarily wasted. Too often the consumers pay comparatively little attention to the question of getting the best illuminating results from the method of lighting adopted. Many cases can be noticed in which recourse has been had to extravagant methods of illumination without due regard to expense, one half, or perhaps even two-thirds of the actual light produced remaining useless. In other cases the reverse has happened, too little light being used from motives of mistaken economy, and even that not always turned to the best advantage.

The amount of money expended in the production and use of light in this country is very large, and it seems safe to say that in no other department of modern commerce is there so much expended with so little knowledge of the best methods of obtaining the desired results. It is estimated that the expenditure for lighting in this country exceeds 36,000,000*l.* per annum. We believe that, by paying attention to the correct use of illumination, the possibility of reducing the waste to a minimum is well worth taking into consideration. It was therefore thought that the issue of a special Magazine devoted to the furtherance of the science and art of illumination would be cordially received by all classes.

It is not only the small consumer who may expect to secure great economies by the use of the most up-to-date methods of lighting, but there are many public and other buildings, such as factories, ware-

houses, hotels, restaurants, clubs, theatres, &c., in which the methods of illumination adopted may be greatly improved, and considerable economies thereby effected.

The moment is therefore opportune for the issue of a Magazine devoted entirely to matters of illumination, and, realizing that the problem is one of international importance, we have endeavoured to give 'THE ILLUMINATING ENGINEER' an international character, and so shall include in our pages articles contributed by the British, Continental, and American authorities.

The Editor has recently visited the United States and the Continent, with the object of ascertaining the views, and securing the co-operation, of those connected with the various aspects of illuminating engineering. We are glad to say that, in addition to our British and American helpers, we have been promised the cordial co-operation of many of the leading continental authorities, amongst whom we may mention the following :—

Dr. Blau, Dr. Bloch, Dr. Blondel, Dr. Richard Böhm, Dr. Bunte, Dr. Grau, Mr. Guiselin, Dr. Herzog, Mr. Kremenetzky, Dr. Krüss, Dr. Lux, Dr. Monasch, Mr. Pihan, Mr. Predit, Mr. Remané, Dr. Rubens, Dr. Ruhmer, Dr. Wedding, &c.

We feel, therefore, that the response which has greeted our efforts fully justifies the conviction that the correct treatment of illumination is not only of national, but of international importance.

The variety of readers to whom our Magazine will appeal is very wide, and it has been thought advisable to make the contents of our first issue as representative as possible, in order to illustrate the general nature of the ground which we propose to cover. We shall, in turn, pay special attention to the different aspects of illuminating engineering, in order that all sides of the question will ultimately receive their due share of consideration.

In this issue we desire to draw attention to the articles dealing with the influence of light on eyesight. We also wish it to be understood that 'THE ILLUMINATING ENGINEER' is independent of any particular system of illumination, and therefore, in our editorial columns, we shall deal with all systems *impartially*. Our Magazine constituting neutral ground, we should like to mention that our columns are at the disposal of all authorities connected with the different aspects of illumination, in order that our readers may have the opportunity of drawing their own conclusions as to the relative merits of the different systems of illumination now in use. We shall also publish, for the benefit of the lay readers of the Magazine, a series of popular articles, in which technical data will be reduced to simple forms and expressions, so as to be readily understood.

The question of illumination concerns not only the lighting engineer and the consumer, but the points of view of, among others, the architect, the oculist, and the physiologist, also deserve great consideration. There is a need at the present time to bring together those who are interested in all these various sides of the question, and, until this can be done, we maintain that illumination cannot receive suitable recognition as a science or an art.

There are many cases in which special knowledge, of great value to the illuminating engineer, is not readily available in a form applicable to general problems of illumination. As an illustration of this point, we may draw attention to the fact that our conception of illumination and nearly all our methods of measuring light must rest upon the peculiarities of the eye. Naturally, therefore, those who have no knowledge of the physiology of this organ are constantly confronted with results, in photometrical testing and elsewhere, which they find themselves unable to explain.

Physiologists, for instance, have recently been devoting attention to the difference in the behaviour of the eye under the influence of strong and weak illuminations, and the peculiarities of the retina, as regards the perception of colour. Yet the requisite knowledge of this research is almost entirely confined to the physiologists themselves. It is our intention to keep our readers in touch with essential results of this nature, and to bring out the practical aspect of such researches of the specialist, which might otherwise escape the notice of the student in another field.

The need for a more scientific study of the requirements of illumination is now generally admitted. The only difficulty which some have found is the question of the means by which the improvement was to be secured and the different interested parties brought together. We believe that our Magazine will afford the necessary opportunity for those connected with the various aspects of the subject to express their respective views, and that, through our columns, the general public will gradually become familiarized with the merits and faults of the method of illumination they adopt. We trust, also, that 'THE ILLUMINATING ENGINEER' will be the means of ultimately bringing the exponents of various aspects of illumination into personal contact through the formation of a society devoted to the consideration of all illuminating engineering problems. With this subject we will, however, deal in another issue.

ILLUMINATION AND EYESIGHT.

WE have made special reference to this question in our first number, for one cannot read the views of Prof. Scott, Dr. Kerr, &c., without being impressed by the importance attached by them to good illumination, or without feeling that the deterioration in eyesight of school children recorded is, to some extent, attributable to the bad lighting conditions which they condemn.

It seems natural to suppose, too, that trying conditions of illumination, even when they do not appear to directly affect the eyesight, must enormously increase the strain experienced in carrying out a certain piece of work, and so indirectly influence the physical well-being of the worker.

As Dr. Kerr points out, if this is true of the adult, it is yet more applicable to the children in our schools, who are called upon to make what is to them a special effort, at the period of their life when they are most likely to suffer from undue strain.

We feel, therefore, that there is every reason to advocate a more complete investigation of these conditions by those who undertake the inspection of factories and schools and the testing of eyesight.

We know that the illumination by which work is executed is often too weak, that bright sources of light are often so placed that the rays of light fall directly upon the eye, and, so far from assisting the worker, render it difficult to see surrounding objects.

But there are many other questions which are as yet merely matters of conjecture, and can only be authoritatively settled by co-operation of the nature advocated.

An exhaustive system of medical inspection of factories and workshops is in existence, and has done excellent work in other departments. We should like to see these operations so extended as to include particulars of the conditions of lighting occurring in the works they visited.

By this means valuable and authoritative data as to the influence of various systems of illumination on sight and health might be gathered, which would eventually lead to the elucidation of many of the vexed questions of the present day.

The same considerations apply with even greater force to the inspection of

schoolrooms, where the conditions of illumination have been shown to be, in many cases, defective. In this connexion it may be pointed out that the creation of a medical department of the Board of Education, and the presumable extension of the medical inspection of schools under their directions, affords an opportunity of organizing a more complete investigation of the nature we desire.

Much information might also be gained through the experience of the oculist and optician, and the recording of the conditions of illumination under which those who come to them for treatment have been working, especially any marked examples of the influence of any particular system of illumination.

The whole question is one with which the illuminating engineer, the architect and the oculist, are all concerned. Only through their mutual co-operation can we ensure that the various aspects of illumination shall each receive its due share of attention.

We therefore also invite architects to avail themselves of the opportunity given in our columns of exchanging views with others interested in the question of illumination, and bringing forward the aspects of illumination with which they are most intimately connected.

Shop-Window, Library, and Factory Lighting.

In a recent paper read before the Association of Engineers in Charge, the Editor had occasion to allude to the misuse of light as exemplified by the three cases mentioned above.

There can be no doubt that, even in the best streets of London, much of the light utilized for the illumination of shop-windows is not merely wastefully employed, but is actually so displayed as to defeat the object for which it is intended.

Brilliant lights are frequently distributed, either in the front of the window or among the contents of it, in such a way that the prospective customer cannot gaze into the window without discomfort. Everybody has experienced the temporary blindness which follows an attempt to look steadily at an intensely bright object, and has noticed how impossible it is to see into a background behind the light of this description. Whenever one looks at such an object the pupil orifice and retina of the eye adjust themselves in such a manner as to protect the eye from the excessively brilliant illumination, and in so doing cause all moderately illuminated objects to become almost indistinguishable.

The value of a well-lighted window as a means of attracting customers is well worth consideration. Only, let this increased illumination be tastefully and effectively distributed, and let us recognize that such illumination has two distinct objects in view, firstly, to attract the customer, and, secondly, to exhibit the contents of a window to him to the best advantage.

Attention may also be drawn to the unsatisfactory method of illumination employed in many libraries. The lights are sometimes so arranged as to brilliantly illuminate the gangways, where in reality we only require sufficient illumination to find our way about in comfort, while the illumination of the reading tables is often very inadequate. In a library light should serve three chief purposes. It should enable the worker to read, it should illuminate the shelves of books so that the titles are easily recognizable, and it should also illuminate the surroundings with a subdued illumination, sufficiently strong, however, to enable the reader to find his way about. Moreover, when we consider what a serious task for the eyes continuous reading of this description must frequently be, even under the best conditions, the importance of an adequate illumination and of the subdued restful surroundings for the reader will be readily admitted.

The same general conditions apply,

with perhaps even greater force, to the lighting of factories and workshops.

When we consider the very great amount of work carried out by artificial light, and the number of workers employed upon it, we must admit the importance of doing all that is possible to enable this work to be done in comfort. As a rule the cost of light in comparison with the cost of labour is trifling, and any additional expense incurred in providing a satisfactory method of illumination would be amply repaid, firstly, by an appreciable increase in the output and quality of work executed under artificial light, and, secondly, by the improvement in the general health of the workpeople.

The extent to which the workman is guided by the sense of sight in his work is apt to be overlooked. To furnish the most up-to-date machinery and tools, and to pay the present high prices for labour, and then to handicap the worker by insufficient or improperly placed lights, is false economy indeed. Take as an illustration the case of a skilled workman receiving 8*s*. to 10*s*. a day, and compare the cost of the energy consumed by an electric 16 C.P. lamp burning for the ten hours or so or a gas flame, and it will be found to be trifling.

Yet one sometimes notices not only that the methods of illumination employed are inadequate, but that even adequate installations are allowed to fall into a defective state because no particular precautions have been taken for their upkeep. The expense entailed by the regular renewal and inspection of these lamps would be trifling in comparison with the resulting saving of light and labour.

Illumination and the Measurement of Light.

The progress of the study of illumination is necessarily closely bound up with the study of its measurement. We are anxious to know exactly what order of illumination is necessary for each specified purpose, and we can only reproduce this order of illumination at will, by having at our disposal suitable methods of measurement, and by having come to an agreement as to what we want to be measured.

Now that the practical value of measuring illumination is becoming realized, it may safely be predicted that convenient and exact methods of measuring light will gradually be evolved.

We have already taken a great step in realizing the value of so-called "illuminometers"—portable instruments which enable us to measure the actual practical illumination in a street or building. Illumination is naturally influenced by many factors,—the reflected light from wall-papers and surroundings in a room for instance,—which are not taken into consideration by a mere measurement of the intensity of the source employed in a photometrical laboratory. The discrepancies so introduced have continually been a cause of no little confusion in the past.

The need for co-operation is very strikingly exemplified when we come to compare the various data obtainable with regard to the relative sensitiveness of different photometers and illuminometers.

One cannot help feeling that the individual efforts of the past—creditable and valuable in themselves as many of them were — were often restricted in value by the fact that the measurements of different observers were often made under different conditions, and frequently involved differences in nomenclature and definition.

At the present time it is very important that we should be able to agree as to what degree of accuracy can really be expected from photometrical measurements under certain specified conditions, and which of the instruments of the present day are the most sensitive and satisfactory. These questions could be definitely settled by the combined efforts of the various experts in photo-

metry. At present much misconception undoubtedly exists, and can only be removed by the free interchange of views which we are advocating.

In 'THE ILLUMINATING ENGINEER' we propose to publish articles dealing with this important subject.

THE ILLUMINATING ENGINEER AND THE PRESS.

THE technical press in this country have shown interest in matters of illumination by publishing many important articles on this subject, and, in particular, have frequently reproduced or referred to articles published in *The Illuminating Engineer* of New York, or papers read before the Illuminating Engineering Society of New York.

We hope that the contents of our columns will likewise be regarded as of value, and we take this opportunity of expressing our desire of harmonious co-operation for the furtherance of the objects with which we are identified. At the present time too much cannot be done to make the fundamental principles of illuminating engineering more widely known.

We also wish to express our conviction that 'THE ILLUMINATING ENGINEER' covers a field of its own, and will in no way interfere with that occupied by other existing journals in this country.

CONCLUSION.

It may be urged that we have got on all right hitherto without troubling about the defects of our methods of illumination. This suggestion has always confronted any new movement. The truth of the matter is that we rarely realize how bad a thing is until we have something better, and until the question has been more carefully studied. We believe that the time will come when we shall wonder at the crudeness and inefficiency of many of the systems of illumination in use at the present day, and we hope that the work of 'THE ILLUMINATING ENGINEER' will receive due recognition and, being heartily supported, bring about the desired result.

LEON GASTER.

[The Editor of 'The Illuminating Engineer' does not necessarily identify himself in any way with the opinions expressed by his Contributors.]

Obituary Notice.

THE LATE LORD KELVIN.

IT is with deep regret that we chronicle the death of Lord Kelvin, whose long and unique record as a scientist has received world-wide recognition, and requires no comment from us. Lord Kelvin will long be remembered, not only for the greatness of his individual achievements, but also for the wideness of the ground covered by him. Up to the very last he worked indefatigably in the cause of science, with an energy which would have been remarkable in a younger man. This year he accepted once more the Presidency of the Institution of Electrical Engineers, a position which he had filled so illustriously in the past.

In Lord Kelvin the world loses a worker in the field of science who will be regretted indeed. His life should serve as an example to the younger generation of what a scientist's life should be, and supply them with an inspiration to further work in the future.

TECHNICAL SECTION.

Illumination, Its Distribution and Measurement.

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

On May 10, 1892, a paper on 'The Distribution and Measurement of Illumination' was read before the Institution of Civil Engineers, and was subsequently awarded a Telford Medal and a Telford Premium. The paper was published in vol. cx. of the *Proceedings* of the Institution, and is now (with the permission of the Council of the Institution) revised, largely rewritten, and enlarged.

INTRODUCTORY.

Light being an expenditure of energy, "candle-power" is an accurate term, since it is the measure of the rate of expenditure of energy; and the art of illumination is therefore, in a very definite sense, a matter which comes within the province of civil engineers, since it is the art of directing this power for the use and convenience of man. The study of light, its nature and laws, belongs to the science of optics, but even to-day we may look to optical treatises in vain for any useful information on the present subject. Illumination, if alluded to at all, is passed over in a few lines, and it has remained for engineers to study and to work out the subject for themselves. Fortunately the geometrical laws of the distribution of illumination are very simple, and those of photometry are as easy. The physiological side of the question presents some puzzles, and these should receive attention from scientific men who are conversant with the practical difficulties of subjective investigations. Notwithstanding the attention which has been given to the matter during the last few years, the specification of a required illumination of a street or of a railway station would perplex most contractors, and the time has hardly yet arrived for it to be possible to express intelligently how much illumination is required, or, a specification being given, how to execute it.

The vocabularies of the French and English languages are remarkably rich in words connected with light, and such terms as illumination, brilliance, brightness, intensity, and luminosity are generally employed by different writers to express different ideas, and are often used in a confused and vague way. The terms force, power, work, energy, and efficiency have been used by the general public, and will continue to be used, in a very loose and inexact manner; it has been the business of engineers to attach precise meanings to them for their own purposes, to recognize these as the only proper meanings, and to regard a misuse of one of them as a mark of ignorance of the elements of engineering science.

DEFINITIONS AND UNITS.

Light for the present purposes means visible radiation emitted from a flame or incandescent surface, or reflected from a surface. The word "light" is often loosely used instead of intensity of light or quantity of light

In one sense, light is no more a physical quantity than dimness or darkness, it is a general term; in another sense it is luminous radiant energy. The particular terms which denote the chief physical quantities are intensity, commonly called candle-power; flux, or spherical candle-power; illumination; brightness, or intrinsic brilliancy; and quantity of light.

One of the difficulties of this subject is that the use of light and illumination is to satisfy the eye, and the eye is a very poor judge of the physical quantities in question. It is well known that even experts cannot make a tolerable estimate of the candle-power of a lamp by merely looking at it when alight. Electric glow lamps of 16 candle-power and of 8 candle-power or thereabouts are so common, that most people accustomed to use them can make a fairly satisfactory guess whether a single lamp or a number of the same lamps are of 8 or of 16 candle-power. An estimate of the "heft" of a letter, whether it is over or under 4 ounces, the temperature of the air, a length in inches or feet, or the contents of a vessel in pints or gallons can be made by most persons with greater accuracy than a guess at the candle-power of a lamp. Comparative estimates are not much better. It is easy to see that a 12-candle-power lamp gives less light than a 16-candle-power lamp, but it is very difficult to say how much less.

INTENSITY OR CANDLE-POWER.

Candle-power is measured as an intensity in any direction. It is also measured as a flux by the product of a solid angle into the candle-power.

A brief account will be given of the more important standards which have been proposed and used from time to time. Further information may be obtained from the writings of those who have given special attention to the subject.*

* Palaz, 'Traité de Photométrie Industrielle'; J. W. Dibdin, 'Practical Photometry'; W. M. Stine, 'Photometrical Measurements'; Dr. J. A. Fleming, *Journal Inst. Elec. Engrs.*, vol. xxxii.; C. C. Paterson, *Journal Inst. Elec. Engrs.*, vol. xxxviii. Dr. Fleming's paper is followed by a valuable bibliography.

At an unofficial congress at Geneva in 1896 the name "pyr" was suggested for a unit of intensity, and Dr. J. A. Fleming* has proposed the name "lamp" for a 10-candle standard, on the ground that the candle itself having been abandoned, the name need not be retained. It is unfortunate that the word candle-power has taken such a firm position in technical language, and it is curious that we seldom use the word intensity, and its use by the French in connexion with electric current appears to us redundant. If the word candle-power were not so well-established, there would be a better chance of agreeing on an international standard of intensity. If a "daniel" had been in extensive use as a unit of electromotive force there would have been more difficulty in introducing the volt.

The Carcel.—The earliest standard of light was the Carcel lamp, introduced in 1800, and used by Regnault and Dumas for testing gas, and is still employed officially for that purpose in France. It is a colza oil lamp containing a clock-work pump, and has an Argand burner and glass chimney of certain specified dimensions.†

The value in British candle-power was determined by Mr. Sugg in 1870 as 9·6; in 1885 Mr. W. J. Dibdin made it 9·4; while Mr. C. C. Paterson, at the National Physical Laboratory, gave 9·82; and at a photometric meeting held at Zurich in July, 1907, this last value was confirmed. The discrepancies may be accounted for by the many sources of error in the use of this standard, the charring of the wick, the irregular consumption of oil, and the use of a glass chimney. Even in the hands of a single observer successive measurements vary widely.

The British Candle.—The so-called English Parliamentary candle was not more scientific, and hardly more accurate, than the barley-corn, of which three went to the inch. That candle, six going to the pound (but neither

* *Journal Inst. Elec. Engrs.*, vol. xxxii. p. 164.

† See 'Traité de Photométrie Industrielle,' A. Palaz, p. 101.

length nor diameter being specified), and intended to burn 120 grains of sperm per hour, was set up under the Metropolis Gas Act of 1860 as an official standard, only for the purpose of testing London gas.

The German Candle.—In 1868 a carefully specified candle of paraffin was officially adopted by the German Association of Gas and Water Industries, and was called the *Vereinskerze*.

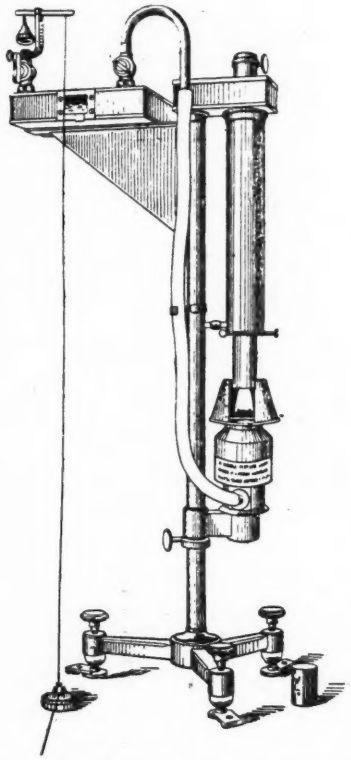


FIG. 1.—THE VERNON HARCOURT PENTANE 10-CANDLE LAMP.*

The Harcourt.— In 1877 Mr. A. Vernon Harcourt described a lamp burning air saturated with the vapour of pentane, a volatile hydro-carbon distilled from petroleum. This has undergone several modifications, and the present pattern, intended to represent ten times the candle-power of the Parliamentary candle, is the official standard of the Metropolitan Gas Referees, and is doubtless an excellent one for their purpose. The liquid pentane is held in a flat tank, and air passing over it, becoming saturated with the vapour, falls by its own gravity through a siphon pipe to a steatite ring or argand burner; and the flow is regulated by a screw cock near the burner, or one on the inlet of air to the pentane saturator. No wick is needed. A tall chimney draws the flame up with a considerable draught, and ensures a steady light. A second outer chimney, concentric with the first, warms the air which is supplied to the flame. No glass chimney is required, but the flame may be inspected for adjustment through a mica window. The top of the flame is cut off in the direction of the photometer by a screen, giving a clear opening of 47 millimetres, but notwithstanding this, the height of the flame must be carefully adjusted. The total height of the apparatus is about 2 ft. 10 in.

The Hefner.—The amyl-acetate lamp, produced in 1884 by Hefner von Alteneck, was subjected to careful tests by Liebenthal, and after certain modifications, was declared to be the official standard in Germany. The pattern certificated by the Reichsanstalt has been adopted by the American Institute of Electrical Engineers, and, provisionally, by the Bureau of Standards of the United States, and was recommended as an international standard at the Chicago Congress of 1893, but was not adopted, for reasons which probably do not exist now. It has been widely recognized for scientific as well as for industrial work.

The container, made of brass, holds abou 4 ounces (115 cc.) of amyl-acetate. The ordinary commercial quality used as a solvent for celluloid is unsuitable, and even the commercially "pure" quality is apt to corrode the container. Unless this is well nickel-plated inside, a cock should be fitted for draining off the liquid after use. A thin German-silver tube, constructed to

* Reproduced by permission of the Gas Referees, from their official description.

the exact dimensions specified by the Reichsanstalt, holds the wick. Two toothed wheels, worked by worm gear, feed the wick, and give a fine adjustment for the height of the flame. A miniature camera with lens and ground glass is carried on a support at the side. A horizontal line is drawn on the ground glass, and the flame of the lamp is adjusted so that its inverted image just touches the line. The ordinary wick for spirit lamps may be used, but should be well dried; it should be carefully trimmed level with the top of the tube.

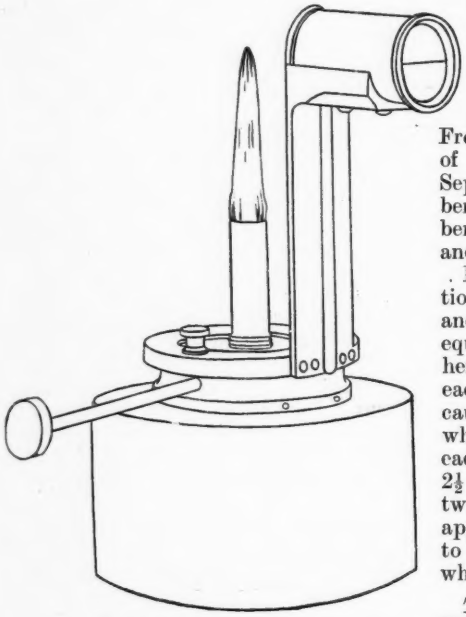


FIG. 2.—THE HEFNER LAMP.

The temperature of the flame, which is of an orange colour, is remarkably low, and owing to the feeble draught, the flame is sluggish and sensitive to very small currents of air. It is not difficult to screen it, and the screens which should always be used in photometric work for keeping the eyes in a sensitive condition may be arranged to protect the flame without causing an artificial upward draught.

Though the flickering of the flame sometimes makes it difficult to check its height on the gauge, it has not so much effect on the candle-power as might be supposed. The temperature of the room has no appreciable effect on the candle-power of the Hefner lamp, and with ordinary ventilation the effect of carbonic acid is negligible. A rise of an inch in the barometer increases the candle-power about $\frac{1}{4}$ of 1 per cent., a difference far beyond ordinary powers of observation, but the presence of moisture is of some importance, and it is unfortunately troublesome to measure. From Mr. C. C. Paterson's* investigations it may be deduced that the Hefner lamp gives its normal candle-power early in May and throughout October. Towards the end of May it begins to fall off, and 1 per cent. must be added. From the middle of June to the middle of August, add 2 per cent.; during September, 1 per cent.; during November, deduct 1 per cent.; during December, January, and February, 2 per cent.; and during April, 1 per cent.

Liebenthal's statement of the relation between the height of the flame and the luminous intensity is an equation which means that when the height of the flame is less than 40 mm., each millimetre change of height causes 3 per cent. change in light; and when the flame is more than 40 mm. each increase of a millimetre produces $2\frac{1}{2}$ per cent. change. No doubt these two linear relations are good tangent approximations, but it is not possible to imagine a change *per saltum* at 40, which is the most important point.

The relative Values of the Standards.—The generally accepted value of the Hefner unit (often written H.U.) has been 0·88 candle-power (or 1 c.-p. = 1·14 H.U.), but at the photometric meeting at Zurich in July, 1907, at which several laboratories were represented, the following values were declared:—

Carcel = $10{\cdot}7_5$ Hefner
Harcourt = $10{\cdot}9_5$ Hefner
Harcourt = $1{\cdot}02_0$ Carcel

* *Journal Inst. Elec. Engrs.*, vol. xxxviii. p. 276.

The results referred to may be conveniently expressed as follows, the subscript figures being approximate.

	Carcel	Harcourt	Hefner
Carcel	10	$9{\cdot}8$	$10{\cdot}7_5$
Harcourt	$10{\cdot}_2$	10	$10{\cdot}9_5$
Hefner	$0{\cdot}93_2$	$0{\cdot}91_3$	1·0

The difference between 0·88 and 0·913 is rather surprising, being more than 3½ per cent., and may indicate that the Harcourt is somewhat less than ten times the value generally taken as the British candle, or that it has been used otherwise than according to the standard manner.

Assuming that a change of 1 mm. in the height of the Hefner flame changes the light by 2¾ per cent., a height of 43½ mm. will correspond with the value 0·913, and a height of 45 mm. will correspond with the value 0.88. These differences are too great to be marked as lines on the ground glass of the gauge, but an adapter can easily be made to raise the whole gauge. The flame burns equally well at this height, which gives one candle-power. Mr. J. W. Dibdin found that the height of an amyl-acetate flame had to be increased to 51 millimetres to give one candle-power. This, according to Liebenthal's formula would mean that one candle-power is equal to 1·275 Hefner units. It is difficult to account for this discrepancy.

The Violle.—More than one attempt has been made in France to set up the standard invented by Violle, and proposed for international adoption at the Electrical Congress at Paris in 1881. The standard is the light emitted in the normal direction by one square centimetre of the surface of molten platinum at the temperature of solidification. The cost of the apparatus is as formidable as the difficulty of using it. In the earlier patterns about one kilogramme of platinum was melted in a crucible of lime by an oxy-hydrogen blowpipe. When a quantity of water begins to freeze the temperature remains practically constant until it is all converted into ice. The same thing happens when a metal solidifies, and this condition must be seized upon for the photometric measurement. A considerable mass of metal is needed to delay the process for a period long enough to allow photometric observations to be made. The crucible was run out from below the blowpipe, and brought beneath a hollow water-cooled screen of copper in which a circular hole one square centimetre in area allowed the light to ascend to a mirror. Dust, scum on the molten surface, the ascending current of hot air, and other difficulties have not only prevented the Violle standard from coming into use, but have left its value in terms of other standards uncertain. It has been assumed that the Violle was equal to about 2 Carcels.

As long ago as 1844 Draper proposed the use of an incandescent platinum wire for a standard of light, and the idea was so attractive to electricians that Zoellner, Schwendler, Werner von Siemens, Liebenthal, Lummer, and Kurlbaum, and finally Petavel have spent much trouble but have produced little practical result. Mr. J. E. Petavel's researches* show the extreme difficulty of working with molten platinum. It has been left for many years to various International Congresses of Electricians to deal in a desultory fashion with the question of a standard of light, and like the mercury ohm, the Violle standard has been officially adopted again and again at International Congresses by people who had never tried to construct or even to use one, and who were unaware that far greater accuracy may be obtained by less academical methods.

The Bougie-Decimal.—The only other standard which need be mentioned is the bougie-decimal proposed at the Geneva Congress of 1896. It was considered to be approximately one-twentieth of the Violle, or one-tenth of the Carcel, but it was declared to be equal to the Hefner unit.

(To be continued.)

* *Proceedings* Royal Society, vol. lxv., 1899, p. 469.

The Present Status of Acetylene Lighting.

By F. H. Leeds, F.I.C.

For purposes of convenience, the methods employed for the production of artificial light may perhaps, according to the form of the matter or energy transformed, be divided into three classes: (1) The combustion of a gaseous or previously vaporized fuel; (2) the combustion of a non-gaseous fuel yielding light by vaporization and decomposition within the flame; and (3) the use of electricity. Similarly, the problem of producing artificial light may be divided into three phases: (*a*) choice of the actual illuminating agent, (*b*) selection of the method by which it is caused to develop light, and (*c*) adoption of a proper method for utilizing the light efficiently and economically.

During the past twenty years comparatively few changes have come over the processes whereby non-gaseous flame illuminants are made to yield light; and although great improvements have been effected in the use of electricity, the alterations have been rather in important matters of detail than in underlying principles. The employment of gaseous illuminants, however, has undergone so fundamental a change by the invention of the incandescent mantle as to deserve the term revolution. The solid illuminant, *i.e.*, the candle, remains in use as heretofore —inefficient, costly, troublesome, but frequently indispensable. Liquid illuminants survive principally in the form of lamp oil, which is burnt as in days gone by; for although heroic attempts have been made to couple paraffin and denatured alcohol with the Welsbach mantle, the results do not appear to have attained any considerable measure of success. With one exception the actual illuminants available fifteen or twenty years ago are all that are available to-day, but that one exception is so striking as to demand careful and minute attention.

The one exception to the rule just enunciated is formed by acetylene, a gaseous illuminant and fuel which is distributed through a house like any other gas, and consumed from fixed burners broadly resembling those employed for coal gas; but, unlike coal gas, made on the great majority of occasions by the consumer himself in a special piece of apparatus erected within an outbuilding at the back of his residence. Although acetylene has been known to chemists for nearly fifty years, it has only come under the cognizance of the illuminating engineer for ten or twelve, its appearance upon the scene of daily life being post-dated until a suitable method was discovered for preparing it at a low price in simple plant. During its brief life-time acetylene has made astonishingly rapid progress when all the obstacles it has had to encounter are duly borne in mind.

First and foremost amongst these obstacles has been its apparent ease of preparation, which has caused every tradesman and amateur suffering from unrestrained love of the soldering iron to essay the construction of a generator. It is not proposed on the present occasion to discuss in detail the various ways in which acetylene is generated, because the main points now under contemplation are the qualities of the gas as an illuminant, and the scope of its practical employment. Treatment of this character may perhaps appear a placing of the cart before the horse; but actually,

however, a man will not care to study the methods of making a substance the utility of which seems questionable or is altogether unknown to him. Nevertheless the principles involved in preparing acetylene must be mentioned in order that misconceptions may be removed and the paradox uttered above be explained.

Acetylene is generated by bringing a solid body known as calcium carbide (usually referred to as carbide) into contact with water in an enclosed space, the gas evolved by a process akin to effervescence being then led to a storage receptacle or to the actual burner where it is consumed. The by-product of the chemical reaction that takes place between the carbide and the water is a solid body, slaked lime to wit, which, being but slightly soluble in water, remains undissolved even if what is termed by generator builders a large excess of water is present in the apparatus. The mere fact that the by-product is solid might at once have shown a chemical engineer that the process of acetylene generation is encompassed with difficulties, more particularly because the reaction between carbide and water is accompanied by the evolution of much heat, which heat is very liable to act prejudicially upon the operation and upon the resulting gas. If the by-product had been a liquid—if, for example, it had been feasible to decompose carbide with dilute hydrochloric acid—only a simple liquid would have been left, a solution of calcium chloride; and in these conditions the construction of a thoroughly satisfactory generating apparatus would have been perfectly simple. On these grounds a qualified engineer might have seen that much technical knowledge was called for in the design of a good apparatus, and might well have taken the subject up in the early days of the industry. Unfortunately, however, he did not; and it was largely left to men of little chemical and engineering knowledge to devise satisfactory generators by the tedious and expensive method of trial and error. At length the experiments have been brought to a successful issue, and acetylene is produced in most recognized apparatus under conditions and in a manner of which neither chemist nor engineer need be ashamed. A second reason for the comparatively slow progress made by acetylene as an illuminant for residential and larger premises has been and still is, curiously enough, its rapid spread amongst cyclists and motor-car owners.

It is a truism to say that the gas has already proved itself indispensable to the car owner who desires to travel far and fast at night. In this way acetylene has made itself known in almost every corner of the land; but it has done so in circumstances that have not by any means altogether recommended it to members of the general public as an indoor illuminant. As open-air instruments, some of the earlier and most of the later types of motor-lamps have proved satisfactory, their rays of light being, indeed, so powerful as to bring the gas they consume into unmerited disfavour amongst people who do not employ them. Another serious fault has been that unconsumed gas has frequently escaped from them—a matter of no consequence on the road, since motor-car owners are *ex hypothesi* rich, but one which has absurdly, though very naturally, left in the layman's mind the almost ineradicable impression that acetylene itself cannot be burned without the production of an unpleasant odour. The townsman is intellectually aware that coal gas has an obnoxious odour before combustion, though it yields none when burned; but his illogical habit of mind prevents him seeing that the same fact may be (as, indeed, it is) true of acetylene, or realizing that an odourless gas would be a most dangerous thing to introduce into a dwelling-house.

It is an unpleasant necessity to have to write thus unfavourably of vehicular lamps, because cyclists and motor-car owners are so very numerous that, in spite of their small individual consumptions of carbide or purchases of ready-made acetylene, as a class they are most valuable supporters of the carbide industry. According to a recent esti-

mate the present consumption of carbide in France is at the rate of about 20,000 tons per annum, one-tenth of which is decomposed in vehicular lamps. In the United Kingdom their relative consumption is undoubtedly much higher, although precise figures on the subject are not easily procurable.

While recognizing the vehicle owner as a strong supporter of the carbide trade, one cannot help regretting that road lamps often leave such powerful visual and olfactory impressions behind. To counteract all this very little has been done systematically by the trade. Only two or three years ago there was absolutely no co-operation on the part of acetylene engineers, and now there is but little.

An excellent scheme of common advertising was drawn up some time back, but the trade gave it no support. Indeed to this very day Tom usually hints to a possible customer that Dick's generator is very extravagant, and that Harry's is very dangerous, to which both Dick and Harry reply in suitable terms, until the would-be consumer is finally convinced that he had better go dark than employ the gas at all. It must be matter of common experience to all who are interested in the gas to find scarcely one person in a thousand, particularly in country places, which form the true field for acetylene, knows the gas by name or repute, except as the material that is burned in so many vehicular lamps by the members of a class who are not precisely beloved on all hands.

In very truth, however, when properly generated and properly burned, and when the light is properly utilized, acetylene is a most excellent indoor illuminant, possessing properties that render it unrivalled in many directions. Inasmuch as the gas is actually generated by the person who consumes it from a material which is neither bulky nor capable of catching fire, acetylene is available as a trustworthy illuminant in the most isolated country house. Hitherto the only forms of artificial light procurable in such a residence have been the candle and the paraffin lamp. The candle cannot be considered as a serious illuminant except where everything (including fresh air) is sacrificed to the elegant effect given by large numbers of low-power lighting units.

Acetylene has to be generated by the consumer just as paraffin lamps have to be cleaned by him, but whereas the existence of the least odour in a house lighted by acetylene is proof of bad gasfitting on the part of the erector, and is therefore absolutely unnecessary, absence of odour in a house lighted by paraffin lamps is so rare as to be practically non-existent. Again, the labour involved in attending to one or two paraffin lamps may appear trivial, but when, as in the houses of the upper middle class, there are some twenty or thirty lamps to be cleaned and made ready for service every day, the labour required may occupy one person for half that day or more; whereas the labour required by an acetylene plant of smaller, equal, or far greater capacity never exceeds one hour per day, and frequently demands but an hour once a week or so. Thirdly, the fact that a large store of highly inflammable material must be kept, if not actually within the residence, in a position close to it, renders the use of paraffin lamps fraught with very grave danger in respect of fire; and the danger occurs precisely in those neighbourhoods where facilities for extinction are the weakest.

It is not possible for the raw material used in generating acetylene to catch fire under any conditions whatever. Before arriving at an open burner the gas itself can only catch fire if it escapes from the apparatus; it cannot escape from the apparatus unless the plant is defective; if it does escape it cannot catch fire unless, in disobedience to all rules, a naked light is brought near the apparatus; if the escaping gas does catch fire or explode, the accident is limited to the special shed containing the plant, and does not harm the dwelling-house or its inhabitants.

Of course, as acetylene has to be generated (except in special circumstances, as where a public supply of

the gas has been provided) by its actual consumer it is inevitably less convenient than any illuminant which is supplied ready for use to the very spot where the light is required. Hence acetylene, strictly speaking, is less convenient than either supplied coal gas or supplied electricity. (By coal gas throughout this article is meant true coal gas, carburetted water gas, or any mixture thereof.) In nearly every place where a supply of coal gas is to be found, a householder can obtain cheaper light from it than from acetylene, provided always some member of his household spends the time needed to keep the incandescent burners, their glass-ware, their mantles, and their shades in good condition ; but in nearly every place he can obtain a better and cheaper light from acetylene than from coal gas if he retains flat-flame burners. In nearly every place, however, a householder can obtain cheaper heat from supplied coal gas than from acetylene, owing to the fact that the latter affords very much less heat in proportion to its light than coal gas per unit of volume.

In comparison with supplied electricity, acetylene has the advantage of yielding a cheaper light under domestic conditions, and of being consumed through a service and fittings which are cheaper to erect and safer in the matter of fire. It is also cheaper than supplied electricity in the matter of heat development.

Naturally, acetylene finds its most obvious and hopeful future in places where neither coal gas nor electricity is supplied. If the illuminant has to be made by the consumer, coal gas can hardly be considered a rival, as the requisite plant is most costly and unpleasant to manipulate. Similar remarks apply to oil gas ; whilst the plant needed for the generation of current is also expensive and requires constant supervision by a man of technical knowledge, in place of the coachman or gardener, who is perfectly able to work an acetylene installation.

Although the statement made at the beginning of this article was true, that with the exception of acetylene no new illuminant had been discovered within the past fifteen or twenty years, the introduction of the incandescent mantle has wholly changed the conditions affecting another illuminant, which has always been put forward as peculiarly suitable for employment in country districts. This is the material known as air gas, made by partially saturating ordinary air with a certain proportion of a very volatile spirit in an apparatus where artificial heat, over and above manual or motive power, may or may not be required.

The liquid employed is gasoline, petrol, or something of the kind, which, undiluted, burns with a very smoky flame, and which therefore, if only diluted with a limited quantity of air, yields a luminous flame like non-incandescent coal gas. Owing to the extreme volatility indispensable in any liquid used for carburetting air by a cold process, the use of air gas connotes the presence in or about a house of a liquid which is much more readily inflammable and potentially explosive than paraffin lamp oil. For this and other reasons air gas, colloquially termed " greased air " in the States, made little or no progress before Welsbach produced his mantle, but since that date the material has become more popular.

There is a maximum proportion of air beyond which gasoline vapour cannot be diluted, if it is to be consumed in an open burner ; but when it is required only to yield a non-luminous flame intended to bring a mantle to incandescence, the proportion of vapour may be much lower.

Recent improvements have, indeed, been effected in the construction of incandescent air gas burners, which allow the gas itself to be made with such a large proportion of air that the mixture contains a smaller quantity of combustible vapour than corresponds with what is known as its lower explosive limit. The consequence is that if modern air gas escapes very freely into a room, no danger of explosion arises, which, of course, is not true of acetylene or coal gas. Air gas, therefore, appears to be the one rival

cf acetylene in country districts. As a source of heat it is doubtless equal, and perhaps superior, but as a source of light it exhibits four grave defects.

In the first place, in comparison with the solid incombustible raw material whence acetylene is generated, air gas is produced from a spirit, as already mentioned, whose fire and explosion risks it is impossible to exaggerate.

In the second place, being an extremely dilute fuel, all the service pipes and connexions for air gas must be as much larger than those used in the piping of a house for coal gas as the fittings used for coal gas are larger than those required for acetylene. This, of course, means a notable economy in the capital cost of installing acetylene. Thirdly, modern dilute air gas is so nearly devoid of odour that leakages are liable to remain undetected much longer than in the case of coal gas, whilst acetylene has an odour which renders an escape immediately noticeable. Certainly an escape of modern air gas is a matter of little importance so far as danger is concerned; but any escape involves waste of money.

In the fourth place, modern air gas cannot be burned so as to produce light, except in an incandescent burner, whereas acetylene can be consumed in an open burner without any serious sacrifice of economy; and, in contradistinction to incandescent burners, open burners can be turned down, or constructed in the smallest sizes desired.

The position occupied by the incandescent mantle to-day is somewhat peculiar. Its invention, as already stated, has effected a complete revolution in the methods used by the more intelligent sections of the populace for the development of light from coal gas. In the hands of a gas engineer, or even of a person who has some manual dexterity, coupled with the disposition which causes him to maintain his animate and inanimate dependents in the best possible condition, the incandescent burner and mantle is wholly satisfactory. A mantle lasts on an average three months. The burner can, if needed, be cleaned and put together without destroying the mantle upon it. The most modern inverted burners can be taken to pieces and assembled very frequently without causing the mantle to suffer in the least. Reports of the general behaviour of mantles and of the illuminating power they still possess when several hundred hours old are constantly being published in most favourable language, and no one can doubt that the figures quoted are perfectly correct. On the other hand, most householders (not excluding the lady members of their families) are too clumsy and careless to look after the burners properly, while comparatively few of them care to take part in a scheme of "maintenance." Perhaps, too, very many lay householders still retain a dread of gas to such an extent that they scarcely venture to touch so complicated-looking an object as an incandescent burner, or so fragile an article as a mantle. The consequence is that the light given by many incandescent burners of established good quality in private houses, and even in shops, is deplorable, causing the consumer much discontent.

Again, although an incandescent burner adjusted so as to give the highest possible duty is affected slightly by the dirt present in an urban atmosphere and during a London fog, the interference with its functions is smaller than that it suffers when used in the country. During a dry spring and summer the mantles on the burners of all country houses situated near a main road are constantly being subjected to the deposition of coarse road grit raised by motors, which collects round the nipples and chokes the air supply.

For a certain period of the autumn winged creatures of all sorts, unrecognized by the photometrist and unknown to the Londoner, submit the mantles to impact stresses, and suffer for their temerity by obstructing the globes with their cremated remains. Other crawling insects, more cylindrical in shape and inquisitive in nature, enter the air inlets, and, apparently enjoying the warmth, remain alive to obstruct the entrance of primary air and to cause the burners to smoke.

All this will be brushed aside as nonsense or pure special pleading by the citizen gas engineer, but the records kept by the present writer relating to the consumption of mantles in a town as well as in a country residence prove that no fanciful picture has been drawn.

In circumstances such as these can there be any doubt that acetylene, which may be consumed economically in an open burner, may be regarded as superior to air gas, which can only be consumed under a mantle; more particularly when it is remembered that the open flame of acetylene is as steady as the incandescent light of coal gas, has a much more pleasing tint, and that it may be utilized without involving the wanton sacrifice of economy which occurs when coal gas is consumed in a flat-flame burner?

There is yet another point. Part of the advance made in the direction of producing artificial light during the past decade or more has consisted in the construction of illuminating units of ever-increasing strength and brilliancy. Only within the past two years or so has any attention been directed to the fact that there is a limit beyond which the illuminating power of a single unit employed for domestic purposes ought not to be pushed. Whatever illuminant is adopted, the efficiency of a single unit tends to rise with its illuminating power; and competition between paraffin oil, coal gas, and electricity has been such that the rival exponents have felt themselves compelled to exact the uttermost farthingsworth of light from the fuel.

Fortunately a reaction has recently set in, as is exemplified by the appearance of this journal in the United Kingdom, and, we hope, by the early formation of a Society of Illuminating Engineers. For the past two years or so voices in the wilderness have cried out against powerful sources of light, prophesying eyestrain and other diseases of the optical organs. They have endeavoured to proclaim that the evils arising from the use of excessive light are as imminent and disastrous as those accruing from inefficient illumination, and they have demonstrated that a room may be easily lighted satisfactorily and comfortably by the use of numerous small sources of light even at a lower outlay for fuel than by one central burner of enormous power. The term intrinsic brilliancy or specific intensity, as applied to a source of artificial light, is probably so new, that even now many lighting engineers and architects could be found who do not know its precise meaning, or the full significance of the facts that lie behind it. The tendency during the past ten years towards the production of ever more powerful sources of light has greatly increased the specific brilliancy of the illuminants, perhaps the greatest offender amongst such sources as are used for domestic purposes being the incandescent glow-lamp inside its bulb of plain glass.

Naturally a light exhibiting so high a degree of specific intensity as to be harmful to the eyesight can be rendered better in that respect by the application of suitable non-transparent globes, which also hold back the harmful ultra violet rays.

But inasmuch as some loss of light occurs in even the best piece of glass, that light is best for use in a dwelling room which requires the smallest amount of degradation from its original intensity.

The specific intensity of a glow-lamp appears to vary, according to the nature of its filament, from 200 to 1,000 or more C.P. per square inch; whereas a light ought not to be erected and used in such a position that its unshaded rays can enter the human eye if it has a much higher intrinsic brilliancy than some 5 or 6 candle-power per square inch. The incandescent upturned gas burner, in its smallest sizes, is usually stated to exhibit an intensity of 20 to 25 candle-power per square inch; but as the unit increases in size, and particularly when a system of so-called intensified lighting is adopted, the figures become a good deal higher, and may

rise to 100 or more. The specific brilliancy of an inverted incandescent coal gas burner does not yet seem to have been examined by many authorities; but having regard to the general shape of inverted mantles, and the fact that such burners throw a very much larger proportion of the total light they yield in a downward direction than do upturned burners, the specific intensity must be higher (in all probability) than the intensity of an ordinary Welsbach. Bell has quoted the specific intensity of the ordinary acetylene flame as being from 75 to 100 candle-power per square inch, but this is undoubtedly incorrect. Woodwell quotes from 25 to 75 candle-power, which agrees a good deal better with measurements made by the present writer, who has found that the light of such an acetylene burner as is most likely to be employed for domestic purposes does not, or need not, exceed 20 candle-power per square inch. The specific brilliancy of an incandescent air gas flame does not appear to be on record, but it should be of the same order of magnitude as that of the open acetylene flame or the incandescent coal gas burner. Thus acetylene exhibits the advantage of being a light of reasonably low intensity, equal, roughly speaking, to air gas and incandescent coal gas, but having the great advantage of being economically capable of combustion in a non-incandescent burner.

One of the most important lessons to be drawn from a study of the new applied science of illumination has recently been taught by Dr. Krüss of Hamburg, who has ably argued that different lights can no longer be fairly compared one with another by measuring the horizontal candle-power they yield, or even by determining their mean spherical or mean lower hemispherical illuminating power, the proper method being to measure the illumination received from them by a surface lying at some stated distance below the light in a position resembling that of the writing-table or book used in everyday life.

At the present juncture it is impossible to say exactly how acetylene stands in comparison with other illuminants whose emissive powers have been carefully measured, because few determinations have been carried out on the capacities of the gas, except in the direction of measuring its horizontal illuminating power. Lansingh has given curves showing the spherical illuminating powers of various unshaded and shaded ordinary acetylene burners; but, to the best of the writer's belief, figures covering the illumination received on surfaces from such burners still remain to be collected.

At a guess, however, it may be said that the illumination afforded by an acetylene flame should be in proportion to its standard illuminating power, very similar to the illumination afforded by a flat-flame burner consuming coal gas.

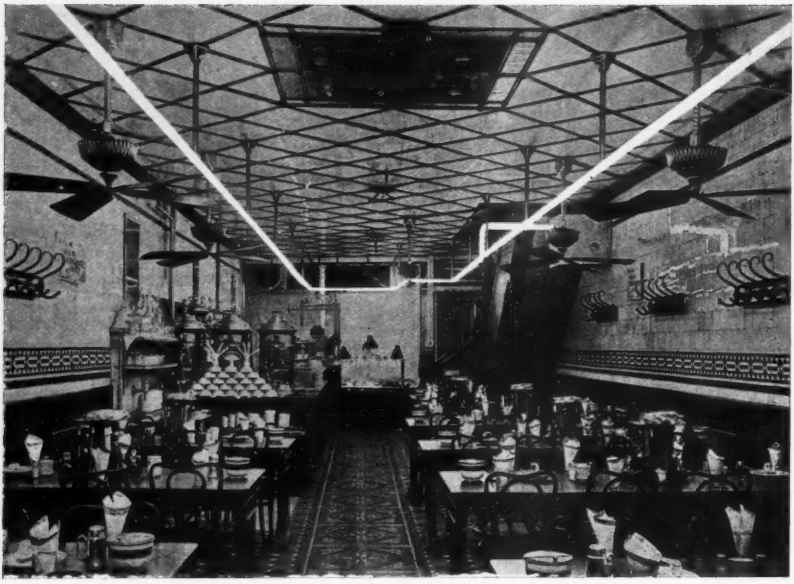
On Vacuum Tube Electric Lighting.

By Dr. J. A. Fleming, F.R.S.

From the time when inventors first turned their attention to electric lighting by incandescence the only line along which their efforts met with any reward, until quite recently, was by the employment of solids rendered incandescent by a current. But although Edison and other inventors nearly thirty years ago spent much time in trying to make use of refractory oxides and metals in the form of wire as the glowing material, no very great success attended their labours, and it was not until Edison and Swan in 1879 and 1880 gave us the completed carbon filament lamp that incandescent lighting started on its practical development. From that date for at least eighteen years the only substance employed as the incandescent material was carbon. The limitations attending the use of carbon were, however, well understood, and in the endeavour to produce a more efficient lamp, inventors went back again to refractory oxides and metals as the material to be heated. In the last eight or nine years much persevering work has resulted in the production of the Nernst lamp, using as the glower a mixture of oxides of earthy metals, the Tantalum wire lamp, and the later Osram or Tungsten lamp.

As in all other matters, no single invention has a monopoly of all the virtues. The above investigations have issued in the production of filaments of materials which can be heated without sensible evaporation to higher temperatures than a carbon filament in vacuo, and have a durability sufficiently great to permit of use in the manufacture of a practical glow lamp. The result has been a marked increase in the so-called efficiency reckoned in the usual unscientific manner in watts per candle; but the drawbacks are, first, the much greater intrinsic brilliancy of the glower, secondly, the inability so far to make lamps of small candle power—say 8 to 10 c.-p. —for working on 100 far less on 200 volt circuits, and thirdly the difficulty in making a high voltage lamp, at least with the materials so far used for metallic wire lamps. The inclusion of the intrinsically brilliant glower in a sand blasted or diffusing globe at once cuts down the useful flux of light per watt of power taken, although it obviates the painful effect produced on the eye by the use of intense point or linear sources of light. On the other hand, difficulties present themselves which detract considerably from the advantages of the improved efficiency. These are best seen by considering an example in detail.

Supposing, for instance, that a large room has to be lit which is to be used as a museum, showroom, drawing office, or workshop, where it is important to have a uniform diffused light and no hard shadows. The present method of procedure in nine cases out of ten would be to distribute about the room pendant carbon filament lamps, and if a sufficient number are employed under shades the desired effect can be obtained. The carbon filament lamp, hung apex downwards, gives, however, only about 60 per cent. of its mean horizontal candle power in a downward direction; and if the electric supply is, as usual, at 200 or 220 volts, the lamps will take 4 watts per nominal c.-p., or probably more. The so-called 16 c.-p. 220 volt carbon filament lamp will generally be found to take 60 to 70 watts or more, and give a light of 9 to 10 c.-p. in the direction of its axis. If then an attempt is made to take advantage of the higher efficiency of the new wire lamps, we



MOORE LIGHTING INSTALLATION, CHILD'S RESTAURANT, NEW YORK.

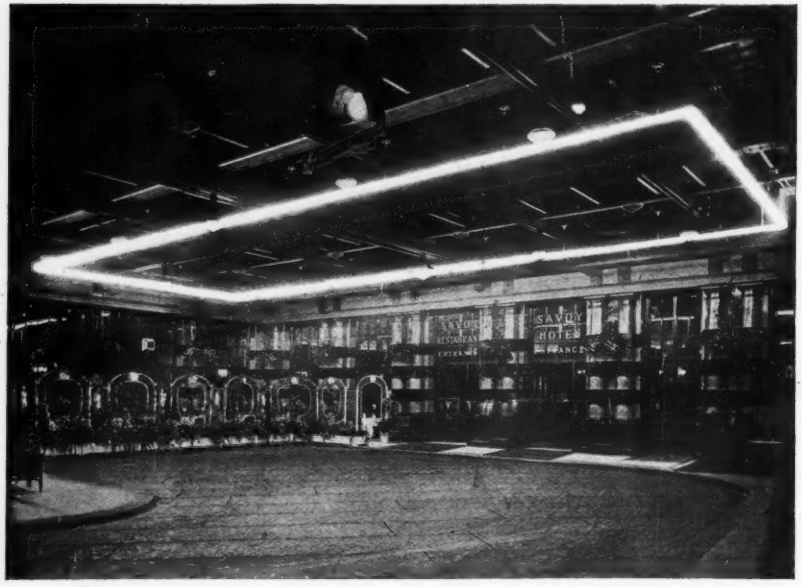


FIG. 4.—MOORE LIGHTING INSTALLATION AT THE SAVOY HOTEL.

are met with the difficulty that 220 volt 16 c.-p. lamps of this type are not yet on the market.

Assuming we place two Osram 32 c.-p. 180 volt lamps in series, although these two together are not taking more power than one 16 c.-p. 220 carbon lamp, yet we should have at that point 64 c.-p. instead of 16 c.-p. Either, then, we have to use fewer points of lighting in the space to be lit, or sacrifice efficiency by diffusing globes, or spoil the uniformity of the lighting by increasing the distance of the sources, or else be unduly lavish of lighting, and so increase the total cost. It will be found that in no way can we obtain the advantage of the greater flux of light per watt spent in the newer illuminants without affecting the distribution of the lighting disadvantageously.

This is altogether apart from any questions as to the life and cost of the newer lamps themselves. So that whilst the unsophisticated householder is implored in the advertisements to adopt the new metallic wire lamp, and so save 70 per cent. of his bill for electric supply, a very little experience shows that there are serious obstacles in the way of this achievement. It is more and more realized that a scientific distribution and diffusion of light is required, and that the mere hanging up of glow lamps in conventional manners and positions is not the highest realization of the functions of the illuminating engineer.

The question then arises, Is there any solution of the problem of interior illumination which, whilst giving us the power of making a proper distribution and diffusion of light, enables us to take advantage of the higher voltages of electric supply now in use and gives an advantage over the widely used carbon filament in respect to the flux of light emitted per watt spent on it? An answer to this question has been given by the improved vacuum tube lighting of Mr. D. Macfarlane Moore, which has now been under test long enough to give proof of its value. Although it has been known in a general way for some time past that light could be obtained by passing a high tension current through rarefied gas, and although many inventors have patented or experimented with vacuum lamps in which the glowing material is a gas and not a solid, it has remained for Mr. Moore to make a forward step of a very remarkable kind in connexion with it.

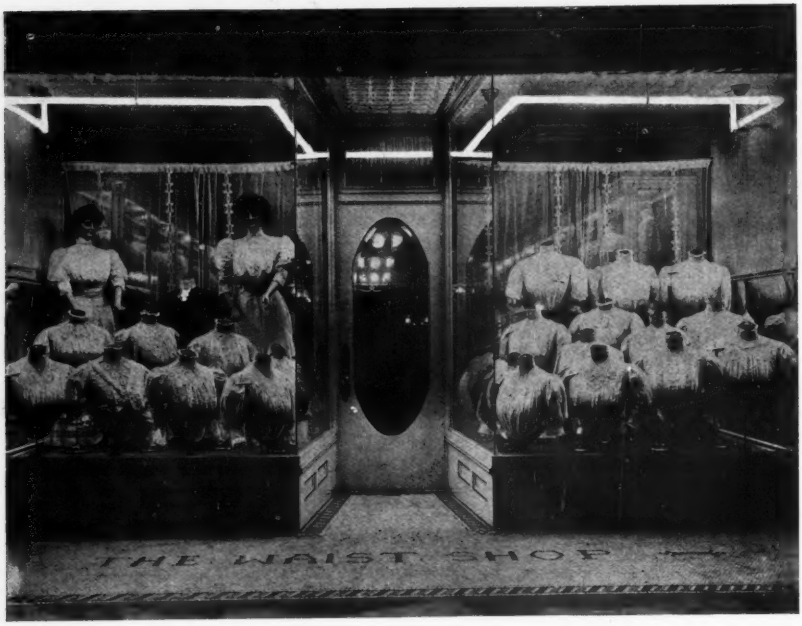
It has long been a familiar fact that when a high tension discharge is passed through a rarefied gas in a glass vessel the pressure in it very soon decreases; that is, the vacuum becomes higher, assuming no leak at the sealing-in of the electrodes.

The gas seems, as it were, to be absorbed. This fact is a familiar one in connexion with Röntgen bulbs, and many have been the devices for lowering the vacuum and making the tube "softer" by reducing the vacuum.

It is generally achieved by heating or sparking against a material contained in the bulb, which has gas occluded in it, whereby the gas is liberated and reduces the vacuum in the bulb. This, however, is not possible in the case of a vacuum tube to be employed in electric lighting. For the last named purpose the process of adjusting the rarefaction of the gas in the tube must be perfectly automatic, and the supply of new gas must not be limited merely by the small amount which can be occluded in, or supplied by, a material sealed up in the vacuum tube.

Mr. Moore has arrived at a practical solution of the problem by the invention of an extremely ingenious automatic valve, which enables the vacuum tube to replenish itself from an external reservoir, or from the unlimited reservoir of the atmosphere as often and as long as required. This valve is controlled by the pressure of the gas on the tube itself, or rather by the change of resistance which accompanies it.

If a tube full of air or other gas has a gradually increasing vacuum made in it the electric conductivity of the tube, for a high tension luminous glow discharge through it, increases as the pressure falls to a certain limit, and then decreases again, so that the gas column has a maximum conductivity corresponding to a certain gas pressure and electric voltage applied.



MOORE LIGHTING INSTALLATION, DRAPERY STORE, NEW YORK.



FIG. 2.

Suppose, then, that such a vacuum tube is attached to the secondary terminals of a high tension transformer which supplies a voltage sufficient to make a luminous discharge through the tube, and suppose that the pressure of the rarefied gas in it has been initially so adjusted that it is a little greater than that which corresponds to maximum conductivity, then as the gas is used up in the tube the conductivity will slightly increase. This will cause the transformer, assuming it to be a constant potential one, worked off electric supply circuits, to give out more current on its high tension side, and so seals the entrance to the vacuum tube. When this plunger is raised it lowers the mercury surface, and exposes the porous plug more or less, so that gas or air can diffuse through it into the vacuum tube. The raising and lowering of the plunger is accomplished by a solenoid, which embraces the outer tube of the valve. The upper part of the plunger contains a bundle of iron wire, and when the current through the solenoid increases it raises the plunger and exposes the end of the porous plug. Hence it will be seen that if this solenoid is included in the primary circuit of the transformer the

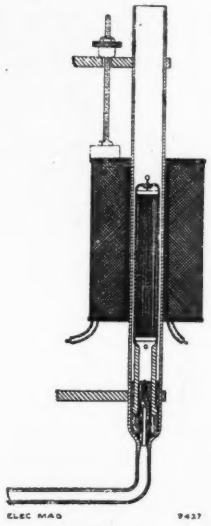


FIG. 1.

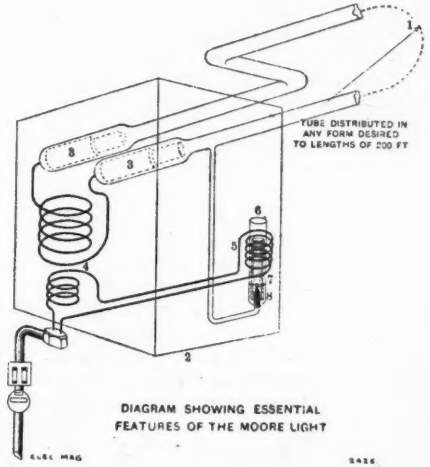


FIG. 3.

and therefore take in more on its low tension side. This increase in current is then made to operate a valve which admits a small quantity more gas into the tube. The valve itself is shown in Fig. 1. From the vacuum tube a side tube is led off, and this is closed by a plug of porous carbon. A wider tube encloses the plug and end of the tube in which it is placed, and a small quantity of mercury, not sufficient to cover the plug, is placed round it. A hollow glass plunger dips into this mercury, and when it is depressed it forces the mercury up to cover the plug, arrangement for admitting air or gas to the vacuum tube can be made automatic. For as the gas in the vacuum tube is absorbed, so its conductivity is slightly increased, and this will increase the current through the high tension coil of the transformer, and therefore through the low tension and through the solenoid, which in turn will lift the plunger and let a little more gas diffuse through the plug into the vacuum tube. The actual arrangement of the Moore vacuum tube is therefore very simple. A long glass tube, 1¾ inches in dia-

meter, is built up in lengths of 6 or 8 feet, the jointing being quickly effected by a special form of gas blow-pipe. This tube can be bent as required, and is supported at some little distance from the ceiling or walls of the room by being passed through brass rings (see Fig. 2). It can be extended up to a total length of 200 feet or rather more. The closed ends of this tube are brought into a small iron box, and are equipped with graphite electrodes, which are carried on platinum wires sealed through the glass. To these ends are attached the high tension terminals of a small transformer stepping up the voltage of an ordinary public alternating current supply from say 220 or 440 volts to 10,000 or 12,000, depending on the length of the tube. For tubes from 40 to 70 feet long a 2 kilowatt transformer is required, and for greater lengths as follows :—

80 to 125 feet a 2·75 k.w. transformer.
130 to 180 feet a 3·50 k.w. transformer.
190 to 220 feet a 4·5 k.w. transformer.

The iron box also contains the above-described feeder valve and solenoid, and some arrangement for supplying the required gas. There are, therefore, no exposed high tension circuits, and in the room to be lit what is distributed is light, and not current, whilst in special cases the transformer box itself can be outside the building and the ends of the vacuum tube brought through the walls.

A very important factor in the illuminating value of the tube is the nature of the gas contained in it. According to Mr. Moore nitrogen is about twenty times better than hydrogen and about twice as good as carbonic dioxide for the same expenditure of electric power on it. Nitrogen is also better than atmospheric air. The light of a tube filled with nitrogen is a rich golden colour, and with carbonic dioxide a whitish-blue. The nitrogen required is easily prepared by aspirating air very slowly over phosphorus. Accordingly the most efficient material for the tube contents is easily drawn from the unlimited supply in the atmosphere. The pressure of the gas in the tube is about one-tenth of a millimetre of mercury, and is maintained at that within 0·01 of a millimetre by the valve.

When actuated by an alternating current of a frequency of 50 a tube filled with nitrogen 200 feet in length and 1·75 inches in diameter takes from 0·25 to 0·3 amperes at a pressure of 10,000 to 12,000 volts. The transformer, assuming it to have a step-up 50 : 1 ratio, will then take 25 or 30 amperes at 100 volts. The tube may therefore be said to have a resistance of 40,000 or 50,000 ohms.

The illuminating quality of the tube and its so-called efficiency are the next points of importance. Mr. Moore gives the illuminating power as 12 Hefners per foot run of the tube for the 1·75-inch diameter tube. The author made some measurements on a Moore tube installed in the courtyard of the Savoy Hotel, London. The tube is 176 feet long, and in the form of a rectangle 60 feet by 24 feet. (See Fig. 4.) It is suspended 30 inches below the ceiling, and 17 feet above the ground. By erecting a special photometer the candle power of 1 foot run of the tube was taken by comparison with a small carbon-filament lamp, itself standardized against Fleming large-bulb standard glow lamps known to be correct. The photometer used was as follows :—

A large wooden box or tube was constructed about 5 feet in length and 1 foot square, and lined throughout with dead black velvet. Both ends were open. At one end two semi-circular nicks were cut out so that when the end of the box was held against the Moore tube and a flap of black velvet thrown over it, it was as if the section of 1 foot run of the tube was placed transversely through the box.

About 3 feet from the vacuum tube a Lummer-Brodhun prism photometer was fixed, the telescope projecting out through the side of the wood tube. On the other side of the Lummer-Brodhun was arranged a small carbon filament lamp attached to a socket sliding on a brass rod, so that on moving the glow lamp to and fro the illumination on one side of the photometer disc could be varied. This

photometer was then calibrated by placing standardized glow lamps of known candle power at various distances from the photometer disc, and noting the position in which the small glow lamp traversed by a fixed and measured current had to be placed to obtain a photometric balance.

Then we have the following problem to consider. The section of the Moore tube 1 foot in length passing across the photometer box has a certain illuminating power per inch run which may be expressed in c.p. Each element of length sends its light to the photometer disc and makes a contribution to the total illumination, which depends upon its absolute distance from the disc and its distance from the centre point of the length of Moore tube intercepted. It is not a difficult mathematical problem to determine from the observed total illumination due to 1 foot run of the Moore tube produced on the photometer disc at a distance of 3 feet the absolute per inch and therefore per foot run of the tube. For if I is the illuminating power of a unit of length, say 1 inch run of the tube, and x is the distance of any small element of length dx of the tube from the centre line of the photometer box, and l is the distance of the photometer disc from the centre of the intercepted length of the Moore, then it is seen that the expression

$$\frac{I dx}{(l^2 + x^2)^{\frac{3}{2}}}$$

must be the contribution made to the illumination of the disc by that element. Hence the integral of the above expression equated to the value of the observed total illumination gives us the illuminating power per inch run of the tube. In the actual experiments the wooden photometer tube was erected on a stage 12 feet high, so that the end of the wood tube was just in contact with the Moore tube, and a flap of black velvet was thrown over it to prevent any light reaching the photometer disc except that coming from the intercepted length of the vacuum tube. The candle power was found to be 9·6 British candles per foot. If the ratio of Hefner to British candle is taken at 0·92 this gives nearly 10·5 Hefners per foot. The current supplied to the transformer of this tube on the low tension side was 20 amperes at 220 volts, and the frequency 60 volts. The actual power was measured by a correct wattmeter, and found to be 3,000 watts. Hence the total candle power of the tube is $176 \times 9{\cdot}6 = 1689{\cdot}6$ c.-p., and the efficiency 1.78 watts per candle. These candle-power measurements, however, give very little information as to the real illuminating power of the tube. For one thing the intensity of light from such a linear source, if very long, does not vary inversely as the square of the distance, but more nearly inversely as the distance, for the same reason that the magnetic field of a long, straight current varies inversely as the distance.

Any valid comparison with other illuminants must be based upon the cost of providing an exactly equal illumination in candle feet on a certain surface. This, however, is in some cases impossible. The cost of producing a certain comfortable illumination on a horizontal surface, say 3 feet above the ground, having a certain uniformity, may be taken as one measure of the value of the light for commercial purposes. In the case of the tube above mentioned the illumination in candle feet was taken by an illumination photometer of the Trotter type at 3 feet above the ground at six equidistant places in the space lit, and found to be respectively 1·05, 1·10, 1·00, 1·00, 1·00, 0·95 candle ft. Such a distribution affords a very pleasant shadowless illumination over an area of 4,800 square feet. Hence the total flux of light per watt is $4{,}800 \times 1 \div 3{,}000 = 1{\cdot}6$.

The courtyard can also be illuminated by thirty ordinary glow lamps of 30 c.-p. each, which are enclosed in glass diffusers. On extinguishing the tube and switching on twenty-four of the glow lamps, the illumination on the same level was found to have fallen to 0·1 candle-foot. In fact, to replace the Moore tube by equivalent glow lamps would require at least 100 16-c.-p. lamps uniformly distributed over the ceiling at the same

height above the ground as the tube, and these of carbon filament lamps would absorb not less than 6 to 8 kilowatts in place of the 3 kilowatts taken by the tube and transformer.

The tube filled with carbon-dioxide, though not having the same efficiency as the nitrogen tube, has a remarkable power of revealing tinted surfaces in daylight colours, so that it is possible to carry on artistic work of all kinds by it as by day. The above figures as to efficiency are not to be taken as the absolute limit of economy. The intensity of the light from the tube can be regulated from 3 or 4 candle-power per foot of tube up to 18 or 20 c.-p. per foot, and the efficiency of long tubes in total candle-power per kilowatt is greater than that of short tubes. The heat produced is negligible, the tubes never rising above 50° or 60° C. in temperature. The character of the illumination given by the nitrogen tubes is remarkably restful to the eye, and from the perfect absence of shadows is an ideal light for museums and drawing offices, or works in which precision work of any kind is carried on.

There are many scientific problems connected with vacuum-tube lighting yet unsolved. Why, for instance, should nitrogen be so much more efficient than hydrogen or than carbon-dioxide? The variation of resistance, with pressure, has also to be more fully investigated in the light of what is now known about conduction in gases. We may not yet have nearly reached the limits of possible efficiency by the use of suitable gaseous conductors. The gas required for inspiration is not large, and in most cases is generated as required. For example, carbon dioxide from marble and hydrochloric acid in a Knipp's apparatus, which stops generation of gas when the gas is no longer being drawn off. The nitrogen is obtained from the air by passing it slowly through an iron reservoir containing lumps of phosphorus.

The actuation of the tube of course requires alternating current, and any frequency above 25 volts can be used. If, however, the street supply is continuous current, then a small rotary transformer has to be interposed to convert the alternating to continuous current. The transformer used is one having a power factor of about 0·65, of special design, whereby changes in the primary current make larger changes in the secondary current than would be the case with an ordinary type of transformer. With, however, an improved valve a transformer with much less reactance can be employed making the tube as a whole have a power factor as high as 0·84.

One point of great importance in connexion with vacuum tube lighting is that the light intensity is directly proportional to the voltage, and not to the fourth or sixth power of the voltage, as in the case of metal wire or carbon filament lamps. Hence a variation of the supply voltage is not seen on the lamps to anything like the extent that it is seen in the case of carbon, or even metallic wire lamps.

The experience gained in the use of this new form of lighting in the United States is sufficient to show that this system of vacuum tube lighting can not only compete with, but surpass, incandescent lighting by glow lamps in the matter of economy. Moreover, in first cost it has the advantage. It does away with all costs of interior wiring, and is, in fact, a form of "wireless electric lighting." The cost of erection of a 200-foot tube and transformer is far less than the cost of installing its equivalent in the form of 100 16-c.-p. incandescent lamps, whilst the operating costs per equivalent candle-feet illumination on a table surface is about half that of carbon filament lamps. This type of vacuum tube lighting has not yet been put into operation to any great extent in Great Britain, but no one who has studied it in its commercial and scientific aspects can have doubts that it is destined to find a large field of utility in connexion with certain classes of public and private lighting.

The Production and Utilization of Light.

By Dr. C. V. Drysdale.

INTRODUCTORY.

A comprehensive survey of technical science at the present day throws into prominence the importance of greater attention to the production and utilization of light, as a subject in which there is the greatest need for and prospect of improvement. The progress of civilization has been largely dependent upon facility of locomotion and the conquering of darkness; and even now, when we are infinitely better off in both these respects than our ancestors of only one or two generations back, we feel more than ever the need of further progress. While, however, in locomotion great advances have been made on scientific lines, and the efficiency of our methods is in some cases fairly high, the production of light, until quite recently, has been almost empirical, and its efficiency extremely low. The proportion of useful light energy, for example, in the case of an ordinary candle to the total energy of combustion is probably only about one-tenth of 1 per cent., for an oil lamp or ordinary gas flame about 0·2 per cent., and incandescent gas not more than 1 per cent. Electric lamps are apparently much better, the efficiency of the ordinary glow lamp being 2·5 per cent., Nernst lamp 5 per cent., metallic filaments about 10 per cent., ordinary arc 10 per cent., flame arc 20 per cent., and vacuum tube possibly 40 to 60 per cent.* But it must not be forgotten that in electric lighting the electrical power is derived from the combustion of fuel through the agency of a heat engine, and only in few instances does the efficiency of conversion exceed 20 per cent. This, therefore, brings down the overall efficiency of electric lighting considerably, and the cost of the conversion from heat to electrical energy has also to be taken into account.

The prodigal wastefulness of our present methods of producing light has been forcibly put by Sir Oliver Lodge in his 'Modern Views of Electricity,'* in which he says that a boy turning a handle could, if his energy were properly directed, produce quite as much real light as is given by the furnaces and boilers of a great steam engine driving a group of dynamos. Although this is probably an exaggerated estimate, there is no doubt that the power of one man, if it could be all turned into light, would suffice for fifty 16-c.-p. lamps, and the total energy consumption of a single wax candle should be sufficient to light sixty such lamps, or to brilliantly light a large mansion.

CONVERSION OF ENERGY.

One of the chief functions of engineering is the conversion of energy from one form to another. Energy, as is well known, is indestructible, and it may exist in the static or potential form, as in a bent spring or lifted weight, a chemically active mixture, or an electrically charged body; or in the kinetic form, as in a moving train or bullet, a revolving flywheel, an

* The estimates of luminous efficiency given by various authorities differ widely. The numbers given here are based upon a determination of the mechanical equivalent of light by Mr. A. C. Jolley and the writer, and are probably fairly correct. This subject will be fully dealt with in a subsequent article.

* Second edition, p. 284, *et seq.*

electric current, or as heat or light.* From the point of view of practical conversion it is most convenient to distinguish five forms of energy: chemical, mechanical, electrical, heat, and light; sound being neglected, or considered as mechanical energy. As light and heat are associated together on account of their vibratory nature we may arrange our various forms of energy as in the diagram (Fig. 1), the transformations being represented by connecting lines. With the exception of the conversion of chemical to mechanical energy and *vice versa*, all these transformations can be effected in either direction, but with very varying degrees of ease and efficiency; and it will be seen that the most inefficient conversions are those from heat to either mechanical or electrical energy, or to light. These are therefore the directions in which there is the greatest scope for, and need of improvement.

In the conversion of heat to mechanical or electrical power, however, theory, while guiding us towards improvement, imposes a bar in the shape of the second law of thermodynamics, which leads to the conclusion that higher efficiencies are only to be gained by increasing the limits of temperature, a conclusion which makes the prospect of great improvement somewhat remote. So far as is known, there is no such bar to the production of a perfectly efficient light, in fact the glow-worm and fire-fly appear to have solved the problem; and we now have a mass of theory and of experimental data which, if thoroughly understood, should ere long enable us to make immense improvements. The recent great advances which have been made in both gas and electric lighting by incandescence have all been the result of a realization of the laws of radiation from heated bodies, and of working on scientific lines.

* Strictly speaking, light energy may be continually varying from the kinetic to the potential form, but it is, at any rate, associated with motion.

NATURE OF LIGHT.

It is obvious that for any such scientific investigation into light production it is necessary to have the clearest possible notion of what constitutes light itself. As is generally known now, the overwhelming balance of evidence is in favour of the undulatory or wave theory of light, which asserts that light consists of waves or vibrations in a medium known as the ether, and of such a rate as to excite the organs of vision. This rate must lie between 400 to 800 billions and vibrations per second, and the disturbance is propagated in free space at the rate of 186,000 miles or 300 million metres per second. Vibrations of lower frequency than 400 billions are only sensible to us as heat; between 400 and 800 billions we have light of colours ranging from red to yellow, green, blue, and violet; and above the latter rate they are known as ultra-violet light, and are instrumental in producing photographic and other chemical effects.

These vibrations in the ether are set up by the luminous source which must therefore itself be in a state of vibration. The kinetic theory of heat tells us that all bodies at ordinary temperatures are made up of particles or molecules in rapid agitation, and as the temperature is increased the rate of motion of the particles increases with it. When the temperature is raised sufficiently, the body, as should be expected, begins to glow with a dull red light, showing that some of the vibrations have at length reached the rate of 400 billions per second required to produce this light.* This would at first sight appear to be a sufficient explanation of the excitation of the vibrations in the ether, but since Maxwell's electromagnetic theory of light was propounded in 1865 the conviction has been gradually forced upon us that all radiation requires to be stimulated electrically, and that the

* As a matter of fact, at a temperature far below red heat the body will commence to emit a very faint greyish light, which is only visible if the observer has been for some time in the dark.

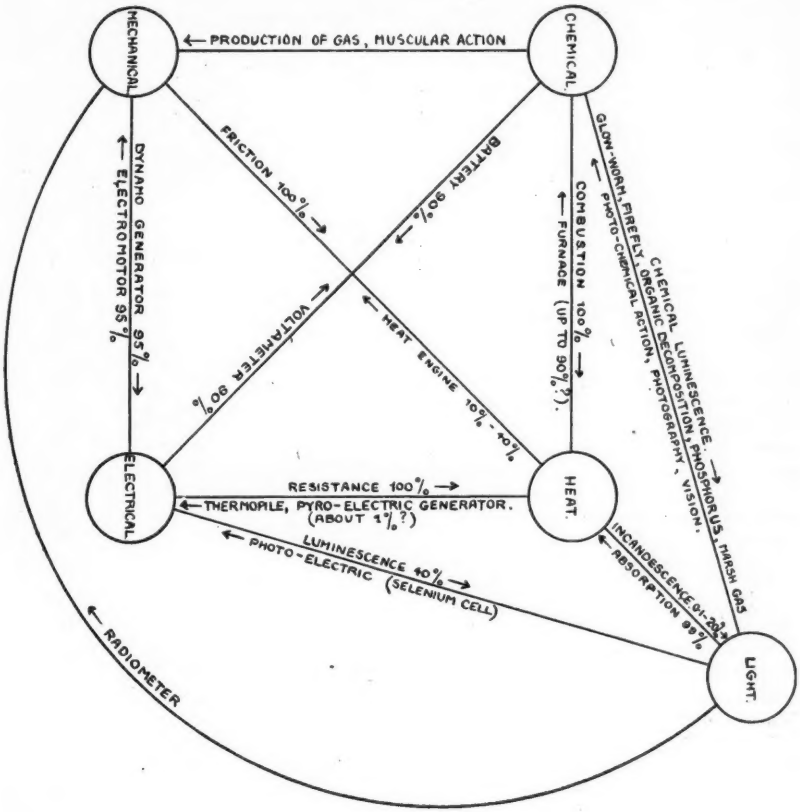


FIG. 1.

motion of uncharged particles is powerless to displace the ether. At the same time we have been aware that in incandescent gases, where the molecules are relatively free from each other's influence, the colour of the light does not depend upon the temperature, but is definitely fixed, as is evidenced by the absolutely fixed position of the bright lines in the spectrum of the gas. This immediately suggests that the vibrations communicated to the ether are not the result of the movements of the molecules as a whole, but rather of movements within themselves, and that the molecules of each gas have special rates of vibration like bells, which give the same note, however they are struck, so long as they are allowed to vibrate freely afterwards.

These two considerations taken together lead us finally to the conclusion that each molecule or particle consists of at least two other particles of opposite electrical charge (as is also indicated from the facts of electrochemistry), and that the collision of these molecules, or any stimulation of them, gives rise to vibrations or distorted orbital motions of these charges or ions, which therefore give rise to electro-magnetic waves in the ether. The positive charges appear always to be associated with the mass of the atom, while the negative charges may exist independently in the form of

much smaller bodies termed electrons; and one way of picturing the ordinary atom is that it consists of a central mass of relatively large size surrounded by one or more smaller electrons, like the sun surrounded by planets. When the molecules are far apart, as in a gas, these vibrations or orbital motions take place with the natural frequency or frequencies of the particular molecule, and we have the ordinary line spectrum. On compressing the gas, however, until the molecules are brought nearer together the collisions are more frequent, and forced vibrations are given out of various rates. This should cause a broadening of the lines of the spectrum, as is found to be the case, while if the gas is condensed to a liquid or solid in which the molecules are not freed for any appreciable time from each other's influence, the vibrations are nearly all forced, and of irregular rates, giving rise to a continuous spectrum or mixed light, as is common in all lighting by incandescent solids.

To more clearly illustrate this theory we may conceive a model such as is illustrated in Fig. 2. It consists of a number of exactly similar tubular bells hung side by side in square order, as in Fig. 3, in such a way that by moving a plate at the top the distance between them can be varied. On the top of the apparatus is a comb of steel strips like those in a musical box, or in the now well-known Frahms speed indicators; each successive reed vibrating in unison with a musical note of higher pitch, like the successive strings of a piano. If now the bells are apart, as in Fig. 3, and they are agitated so as to strike against one another, they should give out an almost pure note, as the intervals during which they are in contact with or interfering with each other will be very short in comparison with the time they are swinging freely and vibrating with their natural frequency. This pure note corresponds to a single vibration or spectrum line of a gas in which the particles are far apart, and will cause one of the reeds only to vibrate.

On now bringing the bells up close together, as in Fig. 4, and again agitating them, it is evident that the number of times they come into contact with one another will be greatly increased, and that the free vibrations of the bells will be interfered with:

"Like sweet bells jangled out of tune."

Other rates of vibrations will be produced, dulling the sound, and causing the reeds adjacent to the first one to be also affected. This corresponds to the broadening of the spectrum line in a compressed gas, or a liquid or solid substance, where the molecules are more tightly packed.

This being said, the problem of efficient lighting is of a perfectly definite character. We have to learn how to stimulate the molecules of a substance, either in the form of solid, liquid, or gas, in such a way as to make it give out electro-magnetic waves of from 400 to 800 billions of vibrations per second, without any outside these limits. The most efficient light, as will be seen later, would be obtained by producing vibrations of about 450 billions per second, which appear to have the greatest effect on the eye; but this would have much the same effect as employing a sodium flame as an illuminant, and all differences of colour would disappear. In order to see objects with natural colours it is necessary to have "white" light, which consists of a mixture of all the rates of vibration between the visual limits. Probably a sufficient approximation to white light would be afforded by light containing seven or eight lines, or, preferably bands, spaced evenly over its spectrum, and it is very probable that the light of the future will be one of this character, rather than one with a continuous spectrum.

(To be continued.)

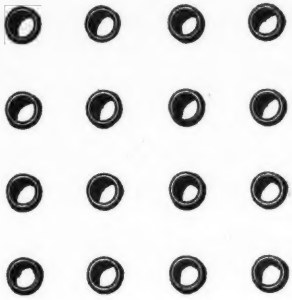


FIG. 3.



FIG. 4.

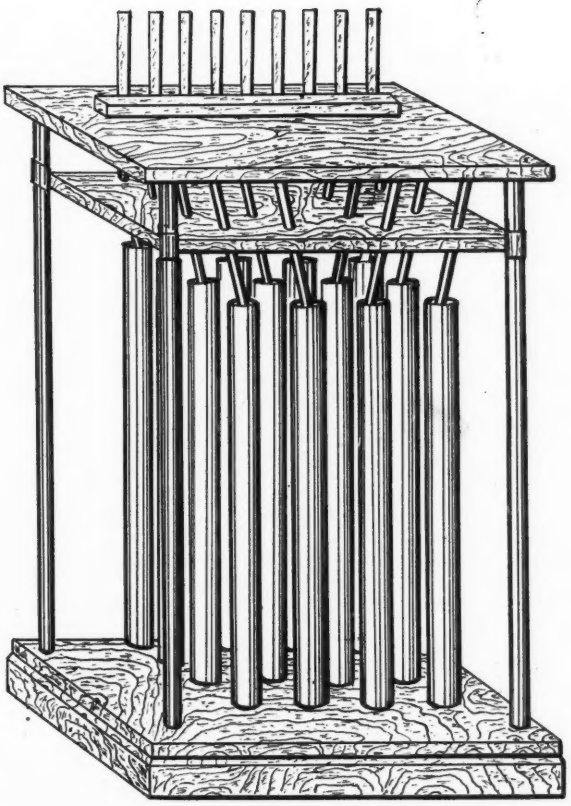


FIG. 2.

Street Illumination.

By Haydn T. Harrison, M.I.E.E.

There is probably no branch of the important work of illumination where the knowledge of an expert is so urgently required as in the matter of lighting streets economically and efficiently. It is difficult to give any reason why this branch has been so neglected, affecting, as it does, both the pockets of the ratepayers and the comfort of the general public; but I am inclined to believe that it is explained by the well-known proverb, "Everybody's business is nobody's business." Thus the nobodies have endeavoured to look after it, and in most cases failed conspicuously.

It is, therefore, very gratifying to me to note that at the recent Convention of the National Electric Light Association at Washington, a specification relating to this subject was drafted. Unfortunately, this only referred to electric lighting, and cannot be considered as a basis on which a general specification could be drawn. Nevertheless, as it indirectly endorses certain views laid down by me in a paper on this subject, read before the Institution of Electrical Engineers at Manchester in 1905, I propose to make certain suggestions, based on these views, which might be of value when drafting a general specification of street lighting.

In this paper I stated that, "In order to judge the lighting of a street, it is only necessary to know the minimum illumination at any point where light is required, because if that illumination is sufficient, it obviously follows that it will be ample elsewhere."

Comparing this statement with the specification above referred to, which states that, "With lamps spaced 200 to 600 ft. apart, the specification for street lamps should define the mean illumination thrown by the individual lamp, in position in the street, as measured at the height of the observer's eye, and perpendicular to the rays, at some point not less than 200 or more than 300 ft. distant, along a level street, from a position immediately below the lamp," it is noticeable that if my suggestion of minimum illumination had been specified, the point of measurement would have been fixed once and for all, namely, halfway between the posts; whereas, by leaving this indefinite, no standard can be arrived at.

The Committee state, as their reason for leaving the distance flexible, that a definitely specified distance "might be unsuitable for purpose of measurement." This I cannot agree with, for the simple reason that at 200 ft. with a ten-ampere arc lamp the illumination would only be about ·015 c.-f. at the most, which is not in any case a sufficiently high degree of illumination to measure with much accuracy. Therefore the photometerist would probably prefer to measure the candle-power of the lamp at that angle which lights the specified point, and calculate the illumination resulting. In other words, to place his photometer at, say, 40 ft. from the post, and at such a height as to intercept the rays to be measured.

This raises another point which the Committee might have considered, namely, that if the illumination at the distance mentioned is to be the basis on which to work, it would be better to specify it on the ground level, thus making it possible for the operator to make the measurement at a more convenient distance from the post and height from the ground.

It is noticeable that the Committee decided that the direct illumination derived from one source of light was the unit to be specified, and with this I am in absolute agreement. Mr. Trotter and others strongly uphold the unit of horizontal illumination, because the light derived from all sources is included therein; but I contend that this unit is misleading,

because in a street the illumination of the road and pavement, which are the only horizontal surfaces, is of comparatively little importance compared with the illumination of the faces of passers-by, numbers on vehicles, doorways, name-plates, &c. For example, a person who does not wish to be recognized stands directly under a lamp, knowing that the light from it will not fall on his face, and that the illumination from the adjacent lamps is too low to make recognition possible. If horizontal illumination were the criterion of good lighting, this would be the most dangerous spot for such a person to stand.

It might be argued from the above that it would be well to specify the direct illumination measured at a lamp-post, but derived from the adjacent lamps; but this would not be satisfactory if the lamps are unequally spaced. I therefore return to my original contention that the best illuminated street is that in which the direct illumination (measured halfway between the posts) is the highest; and I think that in drafting a specification, a clause to the effect that the direct illumination measured at a point halfway between any two sources of light shall not fall below a certain number of candle-feet (or other approved units of illumination) from either source, is all that is required to cover the question of illumination.

In cases of open spaces where lamps are situated in all directions, the point of measurement should be that which is the greatest distance from any source of light.

I would also like to see a clause relating to intrinsic brilliancy introduced into specifications. In the paper above mentioned, I suggested that both the maximum and minimum illumination should be considered, and a limit put on the diversity factor; but I am now inclined to think that something further is required. It is true that the use of large units of light spaced at considerable distances is bad practice, but it is possible to produce excellent results in this way, provided the source of light is reduced in brilliancy by increasing the apparent area. For instance, a 3,000 c.-p. flame arc is less trying to the eye than a 300 c.-p. gas mantle, provided the former is enclosed in an opalescent or other suitable globe. Therefore, if a clause limiting the candle-power per square centimetre of apparent source were inserted, this difficulty would be overcome.

Nevertheless, it would be well to limit the maximum illumination permissible, in order to ensure that, should large units of light be used, they would be erected at sufficient height from the ground to obtain as even illumination as possible.

I would, therefore, suggest that every specification relating to public lighting should contain the following clauses:—

(*a*) That the minimum direct illumination measured at a point halfway between each two sources of light, and at a stated height above the road level, shall not be below a stated figure.

(*b*) That the maximum direct illumination at any part of the street a stated distance above the road level shall not exceed a stated figure.

(*c*) That the candle-power per unit surface of apparent source of light visible from the street by any pedestrian, or person on an ordinary vehicle, shall not exceed a stated figure.

The figure stated will, of course, depend largely upon the class of street, road, or open space under consideration, and the sum which is available for expenditure on illuminating same. But in my opinion the fairest way to deal with a tender of this sort is to ask those tendering to state the actual figures which they guarantee under each clause, and to allot the contract to the tenderer who guarantees the highest minimum illumination, with the smallest diversity factor and the lowest candle-power per unit surface of apparent source of light, for the lowest cost per annum. It is, of course, essential that such guarantee be maintained, but this can generally be ensured, as all firms making genuine offers would be prepared to agree to a penalty clause in the event of non-fulfilment of contract.

Such considerations as the spectrum of the lamps, type of post, and ornamental details do not come within the scope of the illuminating engineer, and can well be left as a solace to those who will be loath to cast from his throne their favourite judge of such matters, namely, the mythical "man in the street."

The Petrol-Air Gas Light.

By W. H. Y. Webber.

It strikes one at first as an example of the irony of things, that after many years of strenuous apostleship of the vacuum incandescent electric light, which has been recommended largely on the score of its not being a light of combustion, and therefore incapable of using up or contaminating the air of enclosed interiors, a real novelty and considerable practical improvement of the world's resources for artificial lighting should arrive in the shape of another flame light.

It is, of course, impossible to order the course of mechanical invention; but one can easily understand that the appearance of the petrol-air "gas" light must arouse a sentiment nearly akin to disgust in the minds of those who had persuaded themselves that the artificial lighting of the future would exhibit some wholly different character. Facts, however, are stubborn; and there is no room for doubt in unprejudiced minds, that the so-called petrol-air "gas" light is something to be reckoned with among the resources of civilization in this kind.

For, after all is said and done, in the vain endeavour to establish for a particular method of supplying a want a reputation for being more "scientific" or "hygienic" than the others, the pressing needs of mankind, which have always an economic basis, will never fail to turn to the cheapest convenient means of obtaining satisfaction.

The necessity for good artificial light remains one of the most imperative calls of a progressive material civilization. Naturally, it is best satisfied in regard to the largest communities; and the flood of light which towns enjoy, while the country is plunged in darkness, is one of the most powerful of the attractions of town life. Consequently, those whose tastes or necessities constrain them to live in the country—which has been defined as "the region beyond the gas-lamps"—or in the less inhabited parts of the globe, miss the good lights of the town perhaps more than anything else. It is, therefore, good news for them that in the new petrol-air light they have at their disposal a really bright, convenient, and cheap means of lighting, competent to reduce very largely the disadvantage in this respect under which isolated houses, mills, churches, hospitals, and so forth, have hitherto lain as compared with town buildings.

I do not believe for a moment that there is any room worth mentioning for petrol-air lighting where either town gas or a public electricity supply can be had cheap. Nobody at this time of day is going to give himself unnecessary trouble over home-made gas, when he can have it laid on from the mains. Something very remarkable and considerable would have to be assured as compensation for undertaking any extra domestic or shop expense and responsibility of the kind in question; and this does not exist.

We see the working of this principle of cutting down individual pains and labour in the disuse of oil lamps and bedroom candles, for all their cheapness and æsthetic merits, by town dwellers. People simply will not be bothered with such things.

In the country and abroad, however, the appeal of the petrol-air light is to those who are eager to do or to pay anything in reason for a brilliant and systematic artificial light, by which people can work or play as they do in the town. It is not my business to discuss the drawbacks of older means of supplying this want. I am disposed to think that the once familiar branch of gas engineering, which laid itself out to provide gasworks for private mansions and country institutions, which was stunned for the time being by the electric light, may yet revive under the influence of the brilliancy and cheapness of incandescent gas lighting, and the convenience of gas cooking and warming.

But, in the meantime, the petrol-air light is available for the purpose at a very small initial and running cost. To pipe a building for gas of any kind costs not more than one-fifth the expense of electric wiring; and the petrol-air "gas" generating apparatus is simplicity itself. It can be had in stock sizes ranging from 20 to 100 lights. The smallest size is naturally the dearest proportionately; but it only costs about 2*l.* per light capacity, and the larger sizes run to 1*l.* 10*s.* per light, or less.

The so-called petrol-air "gas" is not gas at all, but merely air very lightly carburetted with petrol vapour. There is in the system the incidental, but very real advantage, that there is sure to be about a country house or institution somebody who is familiar with the handling of petrol for motor-car work so that the simple rules relating to the carburetting of air for lighting are likely to present no strange difficulties. The most remarkable feature of the system is the extremely small proportion of petrol added to the air—not more than 1½ per cent. All the different makes of plant in the market adhere to this proportion of 98½ per cent. of air to 1½ per cent. of petrol vapour. The main thing to make sure of in selecting a plant of the kind is that it will constantly make this particular mixture, and no other.

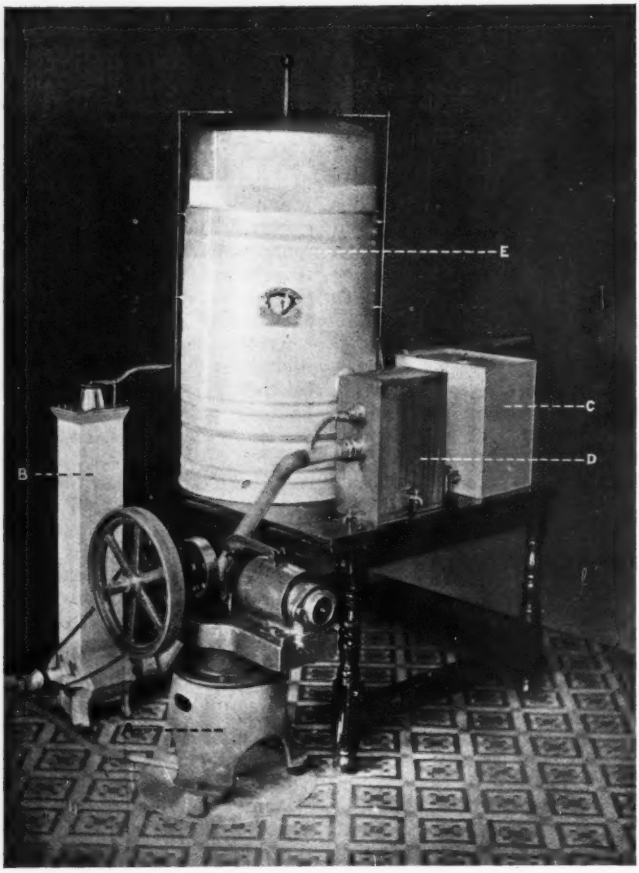
Every plant comprises the elements of a vessel containing the petrol, the carburetter, the small relief gasholder and governor which ensures the automatic operation of production corresponding to the demand, and the hot-air engine for driving the air blower.

The process is necessarily a power one, since the air must be mechanically driven into the carburetter, and so onward. This is effected by the use of the combustible mixture itself, which is caused to burn under the engine. The process is started by pulling round the fly-wheel for a few revolutions by hand, by which the mixing is commenced. As soon as the engine burner begins to work, the rest goes on *ad lib.* The plant occupies a very small space. Of course the petrol tank wants taking care of, but the working parts of the plant are quite harmless. The "gas" is usually advertised as "non-explosive," which is not quite correct. Any gaseous mixture which will burn is also explosible under favourable conditions. This petrol-air blend, however, is so poor a combustible, that the moment it escapes into the air from a burner, or, say, from a leak in the piping, it becomes so diluted by the surrounding air—drowned, so to speak—that it ceases even to be combustible, and consequently cannot explode. This constitutes its safety. So long, therefore, as the machine cannot make a richer mixture, the system is safe enough. A much richer mixture would not burn properly in the burners; so that any mistake in this direction would be promptly indicated.

The cost of making the mixture is variously stated by different manufacturers of the plant; but it is agreed that a gallon of petrol may make about 1,500 cubic feet of it. If the retail price of petrol were to rise to 1*s.* 6*d.*, therefore (it is now 1*s.* 4*d.*), the prime cost of the "gas" would be only 1*s.* per 1,000 cubic feet for the raw mate-

rial. The upkeep of the plant must be inconsiderable, and the labour cost might almost be neglected. For lighting the mixture is useless, except with suitable incandescent mantles, either upright or inverted. Obviously, as the mixture contains all the air necessary for combustion, special burners, which do not increase the air supply, are needed for its combustion.

The consumption per burner is usually about 9 cubic feet per hour for an illuminating power of about 47 candles. This makes a very convenient lighting unit for indoor use. Compared with ordinary town gas, light for light, petrol-air has an efficiency, as above, of 5 candle-power per cubic foot, as against 20 candle-power per cubic foot for town gas burnt in the ordinary way at the pressure of the mains. The latter figure can be doubled at the cost of just such power plant as goes to the production of the petrol-air mixture, in which



"GLOBE" PETROL-AIR GAS MACHINE: A, hot-air motor driving air drawn in through the drying chamber, B, into the carburetter D, on its way to the gasholder and regulator E. C is the petrol tank.

case the comparison stands at 1 to 8, that is to say, town gas at 4*s.* per 1,000 cubic feet is equivalent to petrol-air, when burnt in low-pressure Welsbach lamps of any pattern; or at 8*s.* per 1,000 cubic feet if burnt at high pressure, after the same fashion as the petrol-air mixture.

For fuel purposes the difference is also considerably in favour of town gas, because the calorific power of the petrol-air mixture is 90 B.Th.U. per cubic foot, as against 540 B.Th.U. for common town gas, which is therefore its equivalent at the high price of 6*s.* per 1,000 cubic feet. In point of fact, it is not very useful for cooking or heating purposes, as, although the flame-temperature is high, the bulk required to do any serious amount of heating work is excessive, rendering the management of the flames difficult.

It is claimed as an advantage that the petrol-air mixture has no odour; but clearly this character is not an unmixed benefit, as there is no indication to the senses of any amount of leakage. On the whole, I do not foresee any disabling degree of danger attaching to the proper use of the petrol-air light, although I certainly cannot certify that the plant is "fool-proof." The consent of the Fire Offices must be obtained for the introduction of the system into inhabited premises; and the usual precautions are required with regard to the rather considerable bulk of petrol to be stored. Not the least recommendation of a good plant of this kind is the absence of any evil-smelling residuum to get rid of. The business probably has a future, but should be disentangled from some of the absurd claims put forward by certain of the firms engaged in the trade—claims which, I regret to say, are backed up in some instances by individuals of some pretensions to rank as men of science who ought to know better.

Researches on Reflected and Transmitted Light.

By Dr. Hugo Krüss.

All portions of a luminous image, projected upon a screen, can never appear equally bright to the observer.

This arises, firstly, from the fact that the rays of light which strike the midpoint of the screen, do so vertically, whereas the rays striking the edges do so at some angle depending upon the dimensions of the screen and the distance away of the source of projection; and secondly, from the fact that the observer himself looks at the different portions of the screen at a different visual angle.

As regards reflected light, the variation in brightness is so slight as to be hardly perceptible, provided the screen consists of some good dull white material which is not shiny. But in the case of *transmitted* light it may be very considerable.

The diminution in brightness of a surface, illuminated from the front, follows Lambert's law up to angles of 30 degrees, varying as the cosine of the angle. For greater angles than this, the diminution in brightness is proportionally greater.

According to my experiments the brightness of an illuminated plaster of paris surface appears as follows, when viewed at the angles stated :—

Degrees.	*Brightness.*
0	100
30	87
45	64
60	40

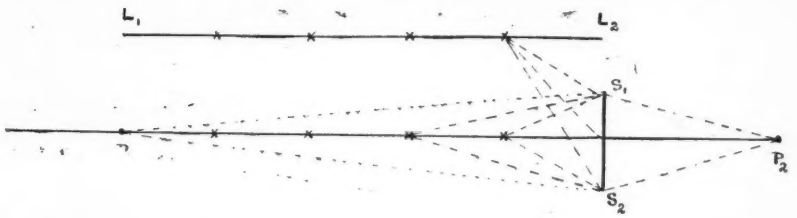
In the case of transmitted light the image is thrown upon the screen in a direction immediately opposite the observer. For this purpose tracing paper—linen, wetted, or soaked in wax—or, finally, a sheet of frosted glass, may be used. More recently it has become customary to use the latter almost exclusively for the purpose.

The transparency of such frosted glass sheets varies very greatly according to the nature of the frosting. In general, however, such plates allow a comparatively large amount of the light falling on them to pass through, so that the image appears very bright, if one looks at it in line with the rays striking the glass, but appears very much darker when observed from other directions. The finer the frosting the more marked is this difference.

In this connexion I have made comparisons between a finely etched and a coarsely frosted glass plate. If one takes the brightness of the image in the direction of the impinging rays as 100, the relative brightnesses corresponding to the angles specified below work out as follows :—

Angle between the direction of the rays striking the glass plate, and the direction of vision.	Finely etched plate.	Coarsely frosted plate.
0 Degrees	100	100
5 ,,	87	89
10 ,,	47	57
15 ,,	9·8	34
20 ,,	3·1	13
25 ,,	1·7	9·7
30 ,,	—	4·8
40 ,,	—	2·4
60 ,,	—	0·7

By the help of these data I have calculated out some figures which illustrate the variation in apparent brightness of the midpoint and right and left extremities of an illuminated screen when viewed from different positions in a room. For this purpose it is necessary to assume certain definite dimensions.



Let us suppose that the illuminated screen S_1 S_2 is 4 metres in breadth, and that the source of radiation P_1 is 25 metres from the screen S_1 S_2, when we are dealing with reflected light. In the case of transmitted light this distance will be chosen as small as possible. I will suppose that the source P_2 is placed 9 metres from the screen S_1 S_2; if the distance is reduced, the conditions are less favourable.

On these assumptions let us calculate the angles at which the rays from the two sources P_1 and P_2 strike the two extremities of the screen S_1 S_2.

This has been worked out in the case of an observer standing on the central line P_1 P_2, and also for one standing on the line to the side L_1 L_2, which is 5 metres distant from the central line P_1 P_2. We can next calculate the apparent brightness of the middle and extreme edges of the screen under these conditions, the distance of the observer being increased at intervals of 5 metres. These values of the brightness are shown in the table, the apparent brightness of the mid-point of the screen, as seen by an observer situated on the central line being again represented by 100. For the opaque screen a dull white plaster of paris surface is assumed, for the transparent screen a coarsely frosted diffusing glass plate.

In the case of reflected light the variation in the brightness of different regions of the illuminated screen are so minute, as to be only perceivable with difficulty by observers standing on the central line; and even in the case of an observer standing on the sideline, the difference is relatively small.

REFLECTED LIGHT.

Distance in Metres.		5	10	15	20
Observer on Central Line	Left edge	93	98	99	100
	Middle	100	100	100	100
	Right edge	93	98	99	100
Observer on Side Line	Left edge	85	95	98	99
	Middle	64	89	95	97
	Right edge	37	64	82	89

TRANSMITTED LIGHT.

Distance in Metres.		5	10	15	20
Observer on Central Line	Left edge	2	11	13	17
	Middle	100	100	100	100
	Right edge	2	11	13	17
Observer on Side Line	Left edge	17	92	97	92
	Middle	2	8	17	38
	Right edge	0	1	2	25

On the other hand, the variation in the apparent brightness of the screen illuminated by *transmitted* light, as seen by an observer in any position in the hall, is so irregular as to render this method of projection inadvisable. The figures quoted are naturally only applicable to the particular variety of frosted glass considered; but this was comparatively well adapted to the purpose for which it was intended, so that very much better results with some other kind of glass are not to be expected.

Finality Reached in Gas Testing.

By W. Grafton.

Uniformity can be secured by using burners which will only yield the maximum light of the gas; and it matters very little what burner is employed so long as this one great object is secured alike for testing the quality of the gas as for the consumer's use.

To secure the maximum light at all times is to obtain finality; but it is questionable whether the good result obtained with modern argands is at the same time the extreme possible for the consumption of 5 cubic feet an hour. Gas-testing law and method dates back a number of years, and therefore it will be well to consider some of the enactments that have been framed in order to secure universal and uniform testing of gas of average quality, but particularly that of from 14 to 16 candles, commonly supplied to the public.

The illuminating test is the best to apply, and far better than a calorific one, because gas is supplied to give light (without the use of a mantle), and it cannot yield light without heat, and consequently its illuminating power is an indirect measure of its heating value. By having the quality gauged only by a calorific test there is nothing to prevent a non-luminous gas being supplied; and besides being not only against the interests of the gas industry, it would entail far more trouble in working to a minimum number of calories per cubic foot than most people imagine.

Most Acts of Parliament relating to the supply of illuminating gas in England specify that the gas shall be burnt at a fixed or nominal 5 cubic feet per hour, also the type of burner, but not always the length of chimney to be employed.

Turning back the pages of history we find that Clause 25 of the Metropolis Gas Act, 1860, provides, so far as London was concerned, that

"the quality of the common gas supplied by any Gas Company shall be, with respect to its illuminating power.....such as to produce from an argand burner having 15 holes and a 7-inch chimney consuming 5 cubic feet of gas an hour, a light equal in intensity"

to so many candles. Here specifically defined are the number of holes in the burner, the length of chimney to be employed, and the rate per hour at which the gas is to be consumed. Nothing is stated as to the kind of gas, and it appears as if it also did not matter how it was burnt, so long as these three requirements were satisfactorily complied with. To this vague description may be ascribed an enormous amount of error and dissatisfaction, for although there is no doubt it was the intention, express and implied, of the Legislature to give the companies the full benefit of the most suitable burner for displaying to the best advantage the quality of the gas supplied to the consumer, it is also quite evident that the worst burner was never contemplated by Parliament, as such would naturally depreciate the quality of the gas.

It is not a case of nominal candle value. The Statute states 13, 14, 15, 16, and the like value in candles, and means what these figures represent, not any approximate or depreciating value. Gas is not like an electric glow-lamp, having one value to-day and another to-morrow; it does not last but is consumed, and so the quality of succeeding supplies of gas must be of the same value as the first, or, in other words, the candle value must

be maintained day by day. This being so, there is no such thing as nominal candle value for gas, nothing, aye nothing, else but the real value, and that must be the "greatest" obtainable by an argand burner, not a value attributed to it by the flat flame, any more than that by the thoria-ceria mantle.

In the Birmingham and Staffordshire Gas Act, 1864, the standard burner then was to have 15 holes and a 7 in. chimney for 14 candle gas. From want of more intimate knowledge of the subject, the Legislature was induced to select a burner which is far from being suitable as a standard. Suppose the gas to be not greater than 14 candles with this burner, a more carefully designed burner would show it to be more, and for which the gas company would gain no credit, because the burner might not be of the same description. The consent of Parliament must be obtained before a 24-hole burner can be employed.

Besides, in those days, and the same belief is held by very many to-day, if the gas be more than 14 candles, it is very probable, when tested by the standard, to be recorded as less than 14, because, if the rate of gas be maintained at 5 feet an hour, the burner will smoke, and consequently give less light. To obviate this, the examiner is compelled to neglect this regulation in the Act, reduce the consumption, and so increase the illuminating power as if read off from the photometer to the standard of 5 feet, by a rule of three calculation. This is a source of error that is increased as the rate of consumption of coal gas is reduced in the argand burner. The following tests show this :—

QUALITY OF GAS AT LESS RATES.

Quantity consumed.	Corrected to 5 ft.
5·0 cu. ft. per hour	14·30
4·9 " "	14·03
4·8 " "	13·90
4·5 " "	12·60

Even the No. 2 Metropolitan burner, with its form of air regulation, cannot avoid this loss of light in greater proportion to the reduced gas, clearly showing that the burner is not properly designed and constructed, for it is possible to make the gas smoke in this burner, and yet yield a higher value for the gas than when not smoking.

Now the rule of three is applicable for estimating the light given in proportion to the quantity consumed, within wide limits, in the Parliamentary Standard Argand (Fig. 1). This is proved by the fact that the results obtained at other rates than at 5 cubic feet are within a tenth of a candle of each other, and this is one degree in uniformity and finality.

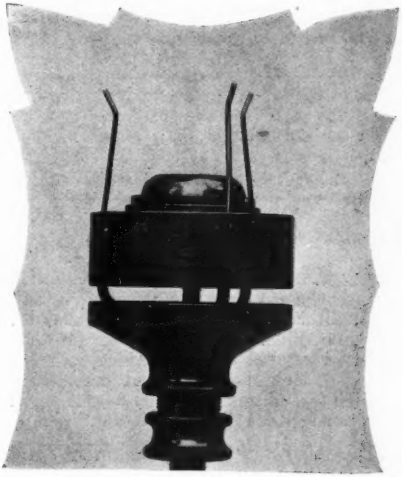


FIG. 1.—PARLIAMENTARY STANDARD 15-HOLE ARGAND.

The burner most generally in use as a standard for gas testing throughout Britain and the colonies is that known as Sugg's burner, the top of which is formed of steatite having 15 holes and requiring a 7 in. chimney. As previously stated, all Acts relating to the testing of gas distinctly state that the gas shall be consumed at a stipulated rate, and shall equal a given number of candles. Now, if the gas be richer than that required by the Act, and no proper provision made for recording its true value, it is, as shown in preceding experiments, very likely that a much less value may be given to it than it really possesses. Nevertheless, the consumer reaps no advantage by

the increase in quality, because he is not bound to consume a specified quantity per hour, but requires only to obtain from each burner a certain amount of light, so that he gets the full quantity of light prescribed by the Act, and in addition, wastes his gas and pays more for it, by reason of its superior quality. These days are not bound up in flat-flame burners, but in incandescent mantle burners, and high quality gas disfigures such with carbon deposits.

The following are examples of Parliamentary testing clauses, dating back to 1867 and 1868, and which are still in force in very many towns :—

I. "All the gas supplied by the Local Board shall be of such lighting power at the place of testing the gas as to produce from an argand burner having 15 holes and a 7-inch chimney, and consuming 5 cubic feet of gas an hour, a light equal in intensity to the light produced by fourteen sperm candles of six to the pound burning 120 grains an hour."

II. Gas Act of 1868 :—

"All the gas supplied by the Company shall, after the 31st day of December, 1868, be of such quality as to produce from an argand burner, having 15 holes and a 7 inch chimney, and consuming 5 cubic feet of gas per hour, a light equal in intensity to 14 sperm candles."

III. Also in 1868 Parliament laid down this rule :—

"The burner for testing illuminating power shall be such as shall be most suitable for obtaining from the gas the greatest amount of light."

IV. Then again as if to emphasize this regulation modern enactments—*vide* The London Gas Act 1905, and in other Acts of more recent date—define the *burner and its use* to be such as to obtain from the gas at "5 cubic feet an hour the greatest amount of light."

The best standard burner for testing gas is, at the same time, the best self-luminous burner for the consumer, as the principles to be observed in the construction of both are identical, and may be stated thus :—

That the quantity of gas to be consumed shall arrive at the point of ignition by an easy and regular flow, and at such a velocity, that after passing through the holes in the top, the carbon particles or illuminants contained in the gas shall be wholly raised to the highest degree of incandescence, yet be fully consumed by the time the flame nearly reaches the top of the chimney.

That the quantity of air for the proper combustion of the gas shall be so regulated, that every portion of the flame shall receive a slow, steady, uniform, but ratioed supply, but not in excess as to destroy the particles so rapidly as to evolve heat without light.

The burner shall be capable of consuming to the greatest advantage in developing the illuminating power, a like volume of any illuminating gas, whether it be coal gas, carburetted water gas, or mixed gases.

The burner that complies with these requirements is the "Parliamentary Standard Argand having 15 holes and a 7 in. chimney." Fig. 2 represents the burner consuming gas without any air regulation, and in which the air drawn in by the chimney is in excess, and is not utilized except in distorting and bunsenizing the flame, so that it is robbed of light, but not of heat. Fig. 3 shows the effect of bringing the air under control by the "perfect regulator." The flame assumes its proper length, and emits the "greatest amount of light" when it "fits" the chimney. It is principally owing to this slow rate of flow of gas and air that argand burners yield, with ordinary illuminating gas, a better light per unit of gas consumed than is possible from flat-flame burners.

The regulator then is used to assist the gas examiner (or consumers) in representing justly the illuminating power, so that if the gas supplied to the public be better than that prescribed by Act of Parliament or agreement, it may be so recorded by the official, in the same manner as it would undoubtedly be if it were below the standard quality. If, however, the gas is so rich in quality that the flame is smoking at 5 feet, the rate may be reduced until the flame burns within the chimney, and with the air regulator

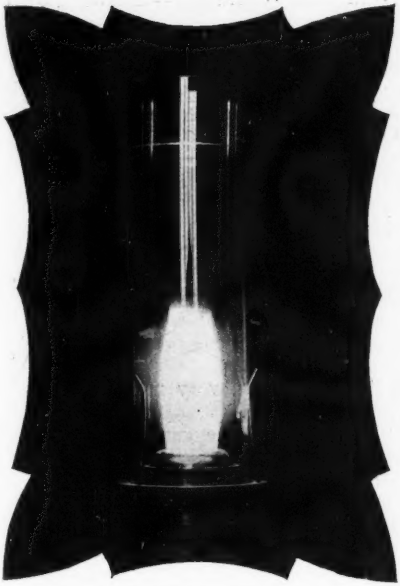


FIG. 2.—FLAME WITH EXCESS OF AIR IN 7-INCH CHIMNEY.

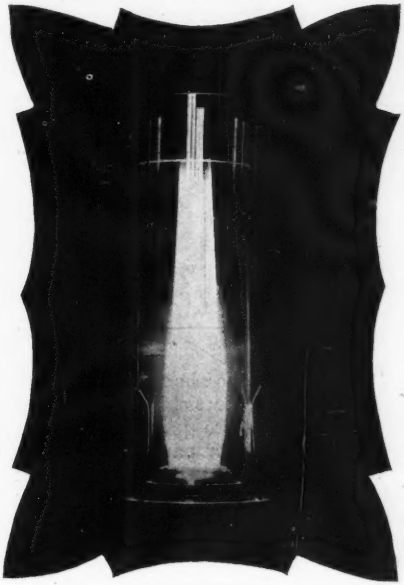


FIG. 3.—"PERFECT" SUPPLY OF AIR AND "GREATEST AMOUNT OF LIGHT."

full open the burner, unlike others, still developes the "greatest amount of light" from that quantity consumed. A simple calculation, based on the amount of light found and the rate of gas used, gives the true value for 5 cubic feet, just as if the 5 feet had been consumed; and so finality is reached by obtaining the "greatest amount of light" capable of being found and prescribed by the Act.

On this point of extra good gas, the London Gas Referees prescribe that

"if the gas is so rich that it cannot be made to burn at the prescribed rate without tailing above the chimney or smoking, or if the burner cannot be pushed far enough away to produce equality of illumination on the photoped, the rate must be reduced until the flame bu ns properly within the chimney."

The No. 2 Metropolitan burner, however, does not obtain for the gas "its greatest amount of light," although the result may be better than that obtainable by the No. 1 London argand using either the 5 cubic feet or 16 candle-flame method.

The following results clearly show the superiority of the Parliamentary Standard Argand, using a 7 in. chimney and 5 cubic feet of gas an hour, over the No. 2 Metropolitan burner, using a 6 in. chimney and similar rate of consumption, by the air regulation and prescribed method of testing.

Some results are also given with a 6 in. chimney on the former burner and a 7 in. one on the (No. 2 Metropolitan) latter, by way of showing a complete comparison, and a proof of uniformity.

COMPARISON TESTS WITH COAL GAS.

Parliamentary Standard Argand.	No. 2 Metropolitan Argand.	
7-in. Chimney. Candles.	6-in. Ch'y. Candles.	7-in. Ch'y. Candles.
14·75	13·87	13·10
14·94	14·28	13·74
15·21	14·70	—
17·07	15·76	—
18·50 (slightly smoking full air).	17·65	—

COMPARISON TESTS WITH CARBURETTED WATER GAS.

Parliamentary Standard Argand.		No. 2 Metropolitan Argand.	
7-in. Ch'ney Candles.	6-in. Ch'ney Candles.	6-in. Ch'ney Candles.	7-in. Ch'ney Candles.
23·95	—	**21·02**	19·46
23·46	—	**20·30**	18·90
21·37	—	**18·11**	17·32
21·10	21·15	**18·20**	—
20·20	20·25	**18·26**	19·11
20·07	20·05	**17·38**	18·90
18·11	—	**16·00**	13·40
16·00	—	**13·97**	13·05

COMPARISON TESTS WITH MIXED GASES.

Parliamentary Standard Argand.		No. 2 Metropolitan Argand.	
7-in. Ch'ney Candles.	6-in. Ch'ney Candles.	6-in. Ch'ney Candles.	7-in. Ch'ney Candles.
15·12	15·24	**14·10**	13·27
15·68	15·79	**14·56**	14·20
17·72	—	**16·27**	15·97
19·31	19·30*	**18·30**	—

* At 4·73 cu. ft. per hour.

The whole of the above figures speak for themselves, particularly the legal methods which are printed in black type to facilitate comparison.

One thing is certain, the Metropolitan burner cannot efficiently consume any gas in order to get "its greatest amount of light," but it can burn the gas, even up to 18 candles, very much as flat-flame burners do.

The future of the gas industry depends upon obtaining from the test burner the whole of the light the gas possesses, and nothing short of this should be accepted by gas authorities if they are to supply a low-priced gas.

The Artificial Illumination of Schools

By S. W. Cuttriss, M.I.E.E.

The question of the efficient illumination of schools is one which has been much neglected in the past, but the Education Authorities are now waking up to the importance of the subject in its bearing on the deterioration of eyesight seen in children of the present generation. The increased stress caused by the modern curriculum necessitates more work under conditions of artificial light, and if this is bad it must react on the nervous system, affecting more or less injuriously the general health as well as the eyesight of the student. The question is not one merely for the electrical engineer, but it is of equal, if not greater, importance when gas is the medium used, and there is undoubtedly ample opportunity for the *Illuminating Engineer* to make it a special study.

By efficient illumination is not meant solely the question of electrical efficiency (when electricity is used) to the illumination obtained, or the most light for the least cost, but, what is of more vital importance to the health of the scholar, the best distribution and intensity of illumination so as to cause no unnecessary strain on the eyes, at the same time giving a cheerful appearance to the room. It is not merely a question of the number and intensity of the light sources, but a consideration of illumination obtained—which means the value of the light reflected from the objects looked upon.

How often does one see a number of naked gas jets or incandescent electric lamps fixed at a height of 6½ or 7 feet above the floor, many of which are in the direct line of vision between the pupil and the teacher or blackboard. The unprotected light shines direct into the eye, which becomes dazzled; the sensitiveness is lost, and the object looked at is only indistinctly seen through the intervening glare. When the eye is cast down to the desk a sensible time elapses before readjustment takes place, the sight is indistinct, and a constant repetition of these violent changes results in an aching or pricking sensation in the eyeball, the effect of unnecessary strain on the optic nerve.

Seeing there is such an objection to having the light shine direct into the eyes, it might be thought that an ideal system would be one giving perfect diffusion with the light sources hidden from view, the light being reflected from the ceiling and walls. Perfect diffusion may be tolerated in some cases and under special conditions, but for class-room lighting it is not to be desired. The great objection is the absence of definite shadow, which is so essential in giving form and solidity to surrounding objects and the idea of perspective.

Further, it would be very inefficient and expensive in operation. The ceiling and walls forming the diffusing surfaces quickly lose their freshness, and the loss of light would be enormous. Experiments with indirect lighting, both by arc and incandescent lamps, have been made both on the Continent and in America, but, so far as the writer is aware, the results have not justified permanent installation. Diffusion is a very good thing, up to a certain point, but it should not be pushed to an extreme, so that the usual effects of moderate light and shade are lost.

In my experience the best, and at the same time most economical system, is to well subdivide the light, and arrange the lamps so that the preponderance of incident rays comes from a position behind the left of the worker. Suspend

COMPARISON TESTS WITH CARBURETTED WATER GAS.

Parliamentary Standard Argand.		No. 2 Metropolitan Argand.	
7-in. Ch'ney Candles.	6-in. Ch'ney Candles.	6-in. Ch'ney Candles.	7-in. Ch'ney Candles.
23·95	—	**21·02**	19·46
23·46	—	**20·30**	18·90
21·37	—	**18·11**	17·32
21·10	21·15	**18·20**	—
20·20	20·25	**18·26**	19·11
20·07	20·05	**17·38**	18·90
18·11	—	**16·00**	13·40
16·00	—	**13·97**	13·05

COMPARISON TESTS WITH MIXED GASES.

Parliamentary Standard Argand.		No. 2 Metropolitan Argand.	
7-in. Ch'ney Candles.	6-in. Ch'ney Candles.	6-in. Ch'ney Candles.	7-in. Ch'ney Candles.
15·12	15·24	**14·10**	13·27
15·68	15·79	**14·56**	14·20
17·72	—	**16·27**	15·97
19·31	19·30*	**18·30**	—

* At 4·73 cu. ft. per hour.

The whole of the above figures speak for themselves, particularly the legal methods which are printed in black type to facilitate comparison.

One thing is certain, the Metropolitan burner cannot efficiently consume any gas in order to get "its greatest amount of light," but it can burn the gas, even up to 18 candles, very much as flat-flame burners do.

The future of the gas industry depends upon obtaining from the test burner the whole of the light the gas possesses, and nothing short of this should be accepted by gas authorities if they are to supply a low-priced gas.

The Artificial Illumination of Schools

By S. W. Cuttriss, M.I.E.E.

The question of the efficient illumination of schools is one which has been much neglected in the past, but the Education Authorities are now waking up to the importance of the subject in its bearing on the deterioration of eyesight seen in children of the present generation. The increased stress caused by the modern curriculum necessitates more work under conditions of artificial light, and if this is bad it must react on the nervous system, affecting more or less injuriously the general health as well as the eyesight of the student. The question is not one merely for the electrical engineer, but it is of equal, if not greater, importance when gas is the medium used, and there is undoubtedly ample opportunity for the *Illuminating Engineer* to make it a special study.

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In my experience the best, and at the same time most economical system, is to well subdivide the light, and arrange the lamps so that the preponderance of incident rays comes from a position behind the left of the worker. Suspend

the lights at a considerable elevation, and protect the eyes from the direct glare of the light by partially obscured globes.

It is not possible toa dhere rigidly to the rule that the light should come from a position over the left shoulder; but there is no reason why a bias should not be given in that direction, so that the strongest shadows are thrown away from, instead of towards the sight. The effect of direct reflection from white paper is to produce eye strain. The sources of light may be shaded from the eye, and yet, owing to the slope of the desk and the angle at which the incident rays strike the paper, reflected rays pass direct to the eyes. Try the effect of this reflection when reading a newspaper, and it will be at once apparent how comfortable reading is interfered with.

The calculation of the number and candle-power of the lamps required to give the desired illumination is a subject which requires separate consideration, and I do not propose to deal with it in the present article. In an article on the 'Artificial Illumination of Interiors,' which appeared in *Electrical Engineering*, January 31st, 1907, the writer discussed the subject from a theoretical point of view. The results then arrived at are shown in Fig. 1.

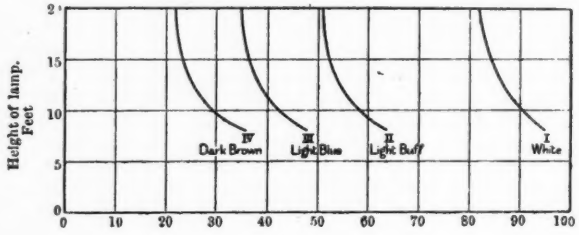


FIG. 1.

The curves indicate approximately the number of square feet of floor area which may be allowed per 1·16 c.-p. lamp, to give an average illumination of 1 candle foot on the floor, premising a white ceiling and various-coloured walls.

In several of the schools with which the author is acquainted the general system of distribution is illustrated in Fig. 2.

Each class-room is fitted with four clusters, each of 3·16 c.-p. clear bulb incandescent lamps, hanging vertically about 7½ ft. above the floor, with 10 in. opal shades over each lamp. The clusters are controlled by independent switches fixed near the door. This gives an "Installation" candle-power of about ·33 per square foot of floor, and approximately 1·4 watts per square foot.

At the time these schools were fitted the plan adopted was considered satisfactory, but experience shows it to have serious defects. The illumination is uneven, being localized too much underneath the clusters; the lamps are not high enough to be out of the line of vision, and the clear globes allow the glare of the unprotected filaments to annoy the vision.

All the switches being near the door, it was found that there was great waste of current by the cleaners, who turned on all the lights when half at the most would have given ample illumination for their purpose.

With a view to improving the illumination, and at the same time reducing the waste of current, I was instructed to make experiments in one of the schools, as it was desired to adopt the most approved system in a large secondary school then in course of construction. The plan finally adopted is illustrated in Fig. 3. Instead of clusters, 10 single-light pendants are used. These are not distributed evenly

over the ceiling, but mostly hang over the desks, and towards the left side of the room when looking at the blackboard.

The lamps are the large bulb type, with half-frosted globes, taking 3·5 amperes at 200 volts. The small opal shades usually supplied with this type of lamp are used, and the bottoms of the globes are 9 ft. above the floor. The "Installation" candle-power is ·28 per square foot of floor, and the

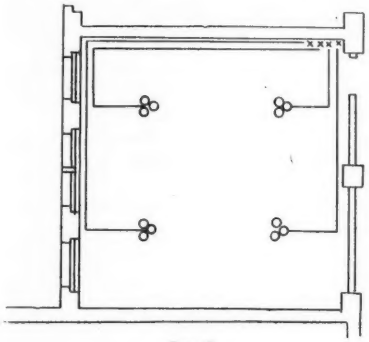


Fig. 2

consumption 1·2 watts per square foot. Although both these figures are less than in the first example, the general effect is much more satisfactory, and the teachers who have had experience of both systems are unanimous in its favour.

It will be observed that only the four centre lamps are controlled at the door, this number of lights giving ample illumination for cleaning purposes. The remaining lamps are controlled by switches near the teacher's desk—a great convenience to the teacher, and at the same time offering less temptation for unnecessary usage.

Class-rooms for special purposes have necessarily to receive individual treatment, but the general principles are very similar, viz., a bright, cheerful light, not too glaring, but yet of ample

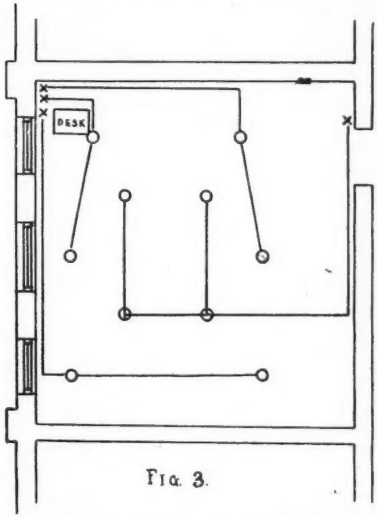


Fig. 3.

intensity for easy working. The sources of light to be well out of the direct line of vision, the lower portion of the globes being frosted, to prevent the eye seeing directly the incandescent filaments or mantle; the light, while being fairly well diffused, not to be subdivided to such a degree as to prevent the formation of definite shadows.

Gas as an Illuminating Agent.

By Norton H. Humphrys, *Assoc.M.Inst.C.E., F.C.S.*

An account of the various industries connected with the work of supplying the demand for artificial daylight would be incomplete without some reference to hydrocarbon gas, popularly known as "coal gas," or simply as "gas." It was the pioneer as regards the distribution of light energy from a central station, and on this account, as well as others, had to encounter special disadvantages. But the gas industry is a hardy plant that will flourish in almost any soil, and from the first it has steadily grown and advanced in public favour. The quantity used for lighting increases year by year.

Gas was introduced in England about one hundred years ago, and, in many respects, it had a premature birth to the extent of fifty years or more. The earliest gas companies had to design and, to a large extent, manufacture the necessary apparatus and plant.

We are now aware that a qualified manager of gas works must have some knowledge of civil engineering and also of chemistry. But in the beginning of the nineteenth century the chemical engineer was an unknown quantity. The chemist never came out of his laboratory, and the engineer never went into one if he could help it.

Under these circumstances the greater part of the pioneer work was carried out by managers who, without the slightest reflection, may be described as technically uneducated.

The intelligent working man—relying on his natural powers of observation, common sense, inventive faculties, and perseverance—made a successful showing, where the science and professional skill of the period was powerless. Such was the state of affairs at the gas-works, and it continued right away through to the burners, which consisted of little more than a suitably shaped orifice at the end of the pipe for the escape of the gas.

As a result, an impression was established to the effect that any intelligent artisan could run a gas-works, and no inducement was offered to attract the better class of engineering or chemical ability. Numerous defects, properly chargeable to ignorance as regards fitting up or the selection of appliances, were accepted as inseparable from the use of gas, and many of these prejudices survive to the present day, although the circumstances under which they originated have long since given way to a more competent and better-informed state of things.

In passing, one cannot but express admiration of the courage and perseverance exhibited by these early workers in laying a firm foundation for an industry of which they knew so little and had great difficulty in studying.

It is only recently that suitable laboratory apparatus for analyzing gas or the products of combustion, for ascertaining calorific value, &c., has been available for the use of the gas engineer. For a long time he had to be satisfied with a photometer and a slip of lead paper. The usual order of things was reversed. When a new manufacture is to be introduced to the public, the first thing to be done is to make some progress as regards a knowledge of its properties and the physical laws concerned.

But we find, even after 100 years' experience, that the leading gas companies are just beginning to organize

lectures and classes for instructing their employees in the A B C of the physical laws concerned in the production, purification, and combustion of gas. The rank and file of the gas-works staff are absolutely without any inducement to increase their technical knowledge. The progress of the industry has been, and is being, hindered by no cause more than ignorance—ignorance in the board-room, on the works, and in dealing with the consumers.

With this state of affairs at the head, one cannot wonder if gas, as a rule, is ignorantly and wastefully used. There is a general tendency to think that anything is good enough for gas, and the only consideration in buying burners and appliances is to get the cheapest goods and labour. The question of efficiency is lost sight of entirely, and it is useless to point out that an accurately made substantial article, designed and constructed on proper lines, and costing, say, 10*s*., may prove cheaper after a twelve-month's use than a flimsy imitation affair that can be supplied for 1*s*.

During the first half or more of its existence, the gas industry had the field to itself to such an extent that it came to be regarded as a monopoly. At that time there were only candles and lamps burning sperm or colza oil to reckon with, and from this cause the consumer was left to his own devices, the gas company considering that their work terminated in the delivery of the gas at the boundary of his premises or at the meter. And this position was forced upon them by the Legislature and by the popular opinion. There was a strong feeling that the gas companies' powers should cease at the meter, and that for the rest the consumer should do as he liked.

But the last forty years have witnessed developments that entirely altered the complexion of that position. With cheap petroleum and electricity in evidence, gas is no longer a monopoly, and it must stand or fall by its intrinsic value, just as any other commodity. One might reasonably suppose that the natural consequence would be a large falling-off of business. Looking at the extent to which electricity is used—the supply and distribution of electricity is not yet thirty years old—at the steady improvement in oil and petroleum lamps, the large reductions in the cost of those liquids, and at the advance in respect to candles, one may well express surprise at the inherent vitality which has enabled gas to more than maintain its position.

The explanation is very simple. The demand for artificial light has greatly increased. A brilliant light in the evening was formerly regarded as a luxury confined to the wealthy. Now it is a necessity to all but the destitute. Not only so, but there is a very large increase in the amount of candle power required to make up that very indefinite result which secures the approbation of the customer as being a "good" light. The demand is for a good light or for plenty of light, but looking at general ideas now prevalent on that point, it is amusing to go back 100 years and read the press reports on the introduction of gas light. A burner that would now be rejected for ordinary use was then likened to the "full splendour of noonday sun."

Our grandparents read small print or did fine lacework under the glimmer of one or two candles. Our parents considered one or two flat-flame burners, giving possibly 10 candle-power each, to be excellent light for an ordinary living room. In the public street, one burner was considered quite enough for 100 yards run.

But the electric arc, the central-draught petroleum lamp, the regenerator gas-burner, and the Welsbach mantle have inaugurated larger ideas. The general demand for all purposes is in the neighbourhood of four to six times as much light as was considered sufficient within the recollection of middle-aged people.

Previous to 1880 the only burners available were the flat-flame and argand, the latter being used to so slight an extent that it may be neglected. The flat-flames in general use consumed 4 or 5 cubic feet of gas per hour, and gave a photometrical value of 8 to 12

candles. Larger burners in clusters, giving up to 500 candle-power, were introduced for public streets and large halls, and regenerator lamps of 50 to 200 candle-power were put on the market.

About ten years later came the Welsbach mantle, promising a duty of 20 to 40 candles per cubic foot of gas used per hour, and gradually pushed all other kinds of burners into a back seat. Some time before 1880, however, the possibility of having more light for less money had been made known, and burners giving a duty of 3 to 4 candles per cubic foot of gas, were introduced by Mr. W. Sugg, Messrs. G. Bray & Co., and others.

The first endeavours to increase the latent resources of gas as a producer of artificial light were in the direction of checking or regulating the pressure at the point of combustion. For obvious reasons the pressure applied at the gas-works to carry the gas to the various burners must be excessive, so far as the greater part of the district is concerned. With the flat-flame burner the quantity of gas passed follows the well-known laws governing the flow of fluids through apertures, and varies inversely as the square root of the pressure behind it. It is usual to express this pressure in terms of an inch of water, and about $\frac{7}{10}$-in., as shown on an ordinary U gauge, is sufficient to give the best result; and if increased appreciably beyond that point, there is not only a larger consumption of gas, but an actual loss of light and steadiness.

A rough-and-ready way of illustrating this point was to stuff a loose plug of wool into the base of the burner, and appliances on this principle, containing gauze, or a second and smaller orifice below the outlet proper, found very general favour, especially the cheaper varieties. But they were simply checks, not regulators, and therefore were far inferior to the governor or regulator burner, which, as its name implies, could be adjusted to give any desired pressure at the point of combustion, quite independently of the inlet pressure, so long, of course, as the same was in excess.

Two very important points were overlooked, or, at any rate, not properly appreciated, at this period.

One was the question of a proper air supply to the flame, especially with regard to the avoidance of draughts or cross currents. At a fairly high pressure the flame would be stiff, but the nearer the adjustment approached the best lighting results, the greater the liability of the flame to flutter and smoke under a draught of air.

And the second was the fact that a globe or shade is something more than a mere artistic appendage. Check or regulator burners were used in offices or public buildings without any protection, and the light was frequently unsteady. This was not only a nuisance in itself, but a flickering flame means soot and other objectionable products of incomplete combustion. It was a long time before relation of the shade or globe to a satisfactory steady flame and complete oxidization of the gas was considered by the makers, who put upon the market all sorts and shapes, colours, and patterns that might be expected to catch on with the public, quite regardless of the fact that many of them tended to increase the troubles just instanced rather than to reduce them. But the general idea is now in favour of simplicity, both as to pattern and colour. The plain clear or opal shade is generally called for, and gaudy colours, elaborate engine-turned patterns, or attempts at high art designing, are things of the past.

The introduction of the Welsbach incandescent burner ushered in a new era, apart from the large economy as compared with the flat-flame. The duty per cubic foot was increased from 2 candles to 20 or more; but that was not all. A great deal has been said about the fragile nature of the mantle; but such was not an unmixed evil either to the consumer or the gas company. It was a blessing in disguise. It necessitated the use of chimneys and other means of guarding the flame from draught, incidentally bringing out the point which the public had hitherto failed to appreciate,

that a gas flame need not necessarily be flickering and smoky. It necessitated a periodical cleaning of the burner, whereas many flat-flame burners were born and died without having experienced contact with a duster or brush, and the lighting effect was largely discounted by dirt.

Under improved conditions of combustion discoloured ceilings and stuffy atmospheres become things of the past. The largely reduced consumption of gas secured by introducing the Welsbach burner of course carries a proportionate reduction as regards heat and products of combustion; but in addition, the protection of the flame from draught is of equal importance as regards securing these desirable conditions. A point that was a matter of some moment under the old system becomes a neglible quantity under the new. Any room so insufficiently ventilated that one or two incandescent gas-burners show an appreciable effect on its atmosphere, is unfitted for human habitation under any circumstances. The ventilation that is necessary, on account of hygienic considerations, apart from our subject, will take proper care of the products of combustion.

A natural result of ignorant and extravagant usage was not only low efficiency, but high bills. The public did not trouble much about the first-named. They were satisfied to walk the streets or to sit at home in what we should now call "darkness visible" if they could save money by the process. Especially in regard to public lighting, the price was a very big first and the quality a small second. One or two astute individuals set themselves up as promoters of gas-consumers' protection or defence associations. The managers of gas-works endeavoured to meet the popular demand by straining every nerve to reduce the price of gas, and their ability came to be measured by their success in this direction.

But while the pence were being taken care of at the works, the cost of manufacture and purification being worked out to the second decimal, the pounds were *not* taking care of themselves at the consumers' burners. The quarterly issue of accounts was always regarded as the opening up of a lively time at the gas-office, in the shape of more or less unpleasant and protracted interviews with indignant consumers.

But very little is now heard in the shape of a cry from the purse. Complaints of the kind are few and far between, partly because with increased sales the gas can be supplied at lower prices, but chiefly because of the improvement in respect to the old wasteful methods, in which direction, however, much yet remains to be done. The cry is now for better service, without regard to expense, and people are willing to pay more, provided they can get better attention, prompt attention to defects, and competent advice as to their requirements.

Under these circumstances there is need for a closer study of the problems connected with illumination, which are complicated by the fact that every room requires a degree of light proportioned to the prevalent colour of the walls and furniture. Certain rules as to so much candle-power per cubic foot of space are useful as a rough guide, but only touch the fringe of successful lighting. In this connexion it is just as well to look over the wall from time to time and see what others are doing. So there is ample scope for a publication devoted to the science and practice of illumination, wherein all parties interested in any branch of this very extensive subject may meet on common ground to consider and discuss the problems and difficulties that have to be encountered.

The Development and Present Position of Gas and Electricity for Lighting.

By Sydney F. Walker.

The keen struggle that is taking place at the present time between gas and electricity for the custom of users of light, recalls the struggle which was also in progress in 1882, when the first Electrical Exhibition was held. At that time there was a very strong feeling indeed against gas, and very strong hopes on the part of the general public that electricity was going to be the light of the immediate future, and that it was going to be very good and very cheap.

Gas had held the field for a number of years previously, and though the electric light had been known and in use to a limited extent for at least thirty years, practically nothing had been done with it until the years immediately preceding the Exhibition. Numerous inventors had been working at the problem of the division of the electric light, and so strong were the hopes in connexion with it, that when Mr. Edison cabled over from New York, a year or two before the Exhibition, that he had solved the problem, gas shares declined some thirty points in value.

At the time of the Exhibition the incandescent lamp had only recently been put upon the market. Mr. (now Sir) Joseph Swan in this country; Mr. Edison in America; Mr. (now Sir) Hiram Maxim, Mr. Lane Fox, and others had been working at the problem, and there were at least four incandescent lamps upon the market, the inventions of those four gentlemen. At the present time the carbon filament lamp which holds the field is made by a process which is practically a modification of that adopted by Mr. Swan at an early date. The Brush arc lighting system had been brought over to this country just previously, and had taught British electrical engineers one method of dividing the electric light. In those days, those of us who were engaged in the struggle could see the numerous faults of the Brush system; but looking back now, we can see what an enormous advance Mr. Brush made by the bold design which he worked out. The date of the actual first advance of electric light would properly be the Paris Exhibition of 1878, when the Jablochoff candle was shown illuminating the Avenue de l'Opera.

But it was the advent of the Brush system in this country which gave the first important impetus to street lighting by arcs. English electrical engineers had been working around the problem of producing a steady arc, but they had found themselves obliged usually to employ one, and sometimes two machines for each arc. Mr. Brush produced forty lamps from each machine, and though the lamps flickered a good deal, they were steadier than the lamps furnished by one or two machines. Mr. Brockie was in the field with his early commutating arc lamp immediately afterwards, and his lamp solved the problem of the lighting of open spaces, such as railway sidings, iron

works, and colliery yards, and so on, practically as well as the Brush lamp. The present writer fitted up two collieries in the Rhondda Valley, in the year 1881, with Brockie commutating arc lamps. But the wink produced by the feed of the Brockie lamp was too irritating for indoor work. The Brush arc lamp, a number of other arc lamps that were on the market at the time, and all the incandescent lamps that were on the market, were exhibited in large quantities at the Crystal Palace Exhibition of 1882, and the public were asked to subscribe for the purpose of laying down electricity generating stations for supplying towns using some of the lamps exhibited.

The public subscribed some twelve millions sterling, but the lighting of towns by electric light, as we know it now, did not come to pass for a number of years afterwards. Enormous sums were paid for the right to use certain systems in certain districts, and very large sums passed into the hands of company promoters. Companies were established in nearly every district, to exploit different systems, but all have gone the way of all flesh many years ago, and the whole of the lamps that were exhibited at that time, and that were on the market, have long since ceased to exist. Gas was supposed then to be about to receive its death blow, and there were many amusing references to the subject. *The City Press* had a coloured cartoon, labelled 'The Gas Director's Dream,' in which a gas director is supposed to be haunted by the faces of the men who were leading the attack on the side of electricity.

But gas was by no means in a dying condition, and did not receive anything approaching a death blow. Careful observers noted a few years after, even when electricity had overcome some of the difficulties it met with, and was making great headway, that the consumption of gas also was steadily increasing. In fact it may be said that, from the time of the Electrical Exhibition in 1882, gas has steadily progressed, both in quality and in the quantity consumed. Gas engineers had previously had the easy time which comes from the absence of competition. Parliament had provided that gas companies should not pay more than 10 per cent. without giving a proportional reduction in the price of gas to its consumers. It was much easier to keep the price of gas up, and to pay dividends at the 10 per cent. with which every one was satisfied, and to spend any money that might be over in building handsome offices, and so on, than to bother with improvements.

From the time, however, of the really active competition of electricity, gas engineers put their shoulders to the wheel, and have been steadily improving their product ever since. In 1882 the price of gas was very high. Five shillings a thousand cubic feet was a very common figure, and six shillings, and seven and sixpence were to be found in small towns. The quality of the gas also was very bad. It burned with a smoky, yellow flame, and numerous gas engineers were at work trying to whiten it.

Further, though it had been known since the discovery of the late Sir William Perkin in 1856, that the impurities of gas contained valuable products, very few gas engineers had made much use of them. After the competition of electricity set in, they turned their attention to that, and though the profits supposed to be available from by-products were not always realized, the gas was more thoroughly cleaned, and gas engineers were able to provide a better article, and to steadily reduce the price.

The competition of electric light, as explained above, increased the consumption of gas. One tradesman perhaps lighted the front of his shop with arc lights, and his neighbour endeavoured to produce an equally brilliant illumination by means of gas, and the gas company reaped more from the neighbour than they lost from the man who adopted electricity. With the advent of the Welsbach mantle in 1893, the tradesman who employed gas was able to make quite as brilliant a display with gas as his neighbour

could with electricity, and at much less cost.

The Welsbach mantle only became practical in 1893, and at the third time of trial. In 1886, and again a few years later, it was introduced to the public with the usual flourish of trumpets, and was supposed to have given the gas companies the weapon they were wanting to enable them to compete with electricity, but in both cases it disappeared shortly after from the market. In 1893 it became a practical success, and gas has not looked back since.

The mantle became successful just in the nick of time. At the moment electricity was going ahead by leaps and bounds. Nearly every town was laying down an electric lighting plant, and there was great enthusiasm for the electric light, while the difficulties in the way of economical production and of distribution had not been thoroughly realized. It may be mentioned incidentally that the Electric Lighting Act of 1882 is blamed for the want of progress between that year and 1888. The real reason was, the problems involved in economical distribution, and even the problem of the dynamo itself, had not been worked out. It was not until 1884, when the late Dr. Hopkinson and Mr. (now Prof.) Kapp worked out the law of the dynamo, that electrical engineers were able to design dynamos with any certainty that they would accomplish what their designers intended them to. From 1884 the progress of electricity has been continuous. There were also difficulties in connexion with electrical distribution, that hardly have a place in this article, but which retarded the progress of electric lighting.

Further, when electricity generating stations were more or less in full swing, it was found that they were very seriously handicapped in competition with gas by the fact that light was only required for a very short portion of the twenty-four hours, by the bulk of those who were disposed to use electricity, even in the winter months, and hardly at all during the summer months. A number of the towns also had handicapped themselves by the adoption of the alternating current, which cut them out of the motor load and prevented the use of storage batteries.

Meanwhile gas was not idle. What is known as high pressure gas was introduced in about 1898 or 1899, the development of the gas mantle enabling this to be done. The principle of high pressure gas may be taken approximately to be the same as that of forced draught. A more perfect combustion is obtained, with an economy in gas and better light. At the Glasgow Exhibition in 1901, portions of the grounds were illuminated by different forms of high pressure gas, and other portions by different forms of arc lamps, and though the arc lamps gave more light individually, when measured photometrically, than the high pressure gas, for practical purposes the grounds illuminated by gas were just as well lighted as those illuminated by the arc light. Since then high pressure gas has steadily advanced, and is in use in a great many towns of the United Kingdom, its use enabling street lighting to be carried out quite as efficiently as by arc lighting, and at a lower cost.

The improvement of the gas mantle also has enabled the gas companies to practically secure the lighting of the side streets, surburban roads, &c., with gas mantles under ordinary pressure. The gas mantle itself has been enormously improved, and the using public have learned to know how to get the best results from it. Later forms are made very much stronger than those of a few years back, so that they can be handled with impunity, and the fittings can be taken down, the dust cleared away from them, and the mantle when relighted is nearly as good as when new.

Against all this, electricity has produced the flame arc lamp, the mercury vapour lamp, the Nernst lamp, the metallized carbon filament lamps, and the metallic filament lamps, and the real struggle is now to commence.

The flame arc lamp gives a very much larger amount of light for the same expenditure of electricity than the ordinary arc, but it is difficult,

under a large number of the conditions ruling, to make effective use of the increase.

The mercury vapour lamp has not "caught on" yet to any great extent, on account of its weird colour, though its efficiency is high, and it appears to be of use for a good many purposes, such as the lighting of offices, printing works, &c. Probably the prejudice against it will be overcome in time, and the public will get used to it, just as they have done to the arc lamp.

The real struggle is between the Nernst lamp, the later forms of carbon filament lamp, the metallic filament lamps, and the later forms of Welsbach mantle. At the present time, in the writer's view, gas is winning, and still holds winning cards. The great advantage possessed by electricity in the matter of convenience is still a very strong card, but gas engineers have learned to copy electricity in a great many respects, and have succeeded in arranging their lights, in many cases, quite as conveniently as electric lights, the pilot light of the gas mantle providing a means of turning lights in and out at a distance. The very high efficiency of the metallic and later forms of carbon incandescent electric lamps give electricity a very strong card, which, if the corporations use it wisely, will enable them to make a good fight with the gas companies.

In the writer's view, there is no question of either light extinguishing the other. Both will go on side by side, the healthy competition between the two leading to continual improvement and continual lessening of cost.

The great danger is the possibility that both may be extinguished by the discovery by some savant of the secret of the light emitted by the firefly. This may seem far-fetched, yet when we remember the enormous number of men and women who are constantly asking nature to surrender her secrets, and the enormously improved instruments with which they are working, also the number of secrets that have been wrested from her during the past twenty years, we should hardly be surprised if the secret mentioned should be discovered at any moment.

Artificial Illumination, and the Education of those concerned in its Production.

By Charles W. Hastings.

The history of gas-lighting has been much before the public during the last few months and almost all that can be said upon the subject has appeared in the technical journals or published in book form; without doubt the best 'History of Gas-Lighting,' is that written by Mr. Charles Hunt, M.Inst.C.E., and published a few months back in commemoration of the centenary of gas-lighting.

The first object of this article is to endeavour to set out the distinct disadvantages under which the gas-maker has laboured for want of a practical and theoretical education; it is no slight upon the intelligence or the industry of the managers of gas-works, of, say, even forty years ago, that they then knew practically nothing about the science of gas-making and were—with but few exceptions—completely ignorant of the most rudimentary laws governing illumination, as such.

The carbonization of coal and the production of gas was carried out by rule of thumb, the Standard of Illuminating Power—which in some cases was fixed by Act of Parliament—was low, the tests for purity and freedom from sulphur compounds were only enforced in the larger cities, lime only was used for purification, ammoniacal liquor, and even tar was allowed to run to waste, and coke itself was often a drug in the market. The gas-maker considered his work complete when the gas was passed into the gas-holder.

Up to perhaps the "sixties" no attention whatever had been given to the improvement of the burner; the first burners—and even those used at this date—were made of iron, and, so far as the writer knows, no attempt had then been made to gauge the size of the aperture from which the gas issued, and certainly no knowledge existed of the rate of flow of gas through pipes. If it was desired to have a quantity of light a six or seven inch bat's-wing burner was recommended. To those whose recollection will not take them back so far, we may mention that the flame from such a burner measured from 6 to 7 inches across, and as the name of the burner implies, was in the shape of the wings of a bat, when fully spread. Pressure was not checked, burners were not governed, and the gas-maker, if he had plenty of gas, was liberal with the pressure; if, on the other hand, he had little gas, he worked at as light a pressure as would travel the gas to the point of ignition.

The engineers and managers of the larger gas companies were very conservative; they met one another upon but very rare occasions, and the provincial men were practically isolated. Up to the "sixties" the bulk of the men in charge of gas-works were drawn from the shops of engineers and contractors who made a business of erecting gas-works, and the best of them were generally mechanics with no more education than that class of artisan acquired, at best, at the local grammar school or otherwise at what were known in those days as the National Schools.

There were, of course, some exceptions, but they were very few, and we venture to say that the Institution of Civil Engineers could not claim as many as might be counted on the ten fingers, even as Associates, and the Members' class was practically unrepresented in gas-works management. Chemical science was quite neglected, laboratories did exist in connexion with the London gas-works and a

few of the larger cities, but we do not remember any one being in charge of them who was either a Fellow of the Chemical Society or the Institute of Chemistry.

In 1864 the first real step was taken to improve the educational position of the gas-maker, for in that year the British Association of Gas Managers was formed, and the first meeting was held under the presidency of the late Thomas Hawksley, who was then, we believe, a member of the Institution of Civil Engineers. He held the office for four years in succession, and was followed by Thos. G. Barlow, the then editor and proprietor of the *Journal of Gas-Lighting*, a very capable man, who made considerable reputation in the Committee Rooms of the House of Commons, and had a large Parliamentary practice in connexion with the promotion of gas and water companies Bills in Parliament.

The starting of the Association, of course, resulted in the gathering together of gas engineers and managers, but the reading of papers, and the discussions upon them, was carried on by only a very limited number of members; some are still living, but the most of them have "crossed the bar."

The great International Exhibition of 1862 gave some impetus to the gas industry; the buildings were of course lighted with gas, and some few new inventions were exhibited. Improvements had been made in the testing and measurement of gas; Messrs. Geo. Glover & Sons, if we remember rightly, exhibited for the first time the cubic foot bottle, also a full range of apparatus for testing meters, &c. Attention was also given to the improvement of gas burners, but still the class of men managing gas-works remained the same.

Directly associated with illumination, it should be noted that in 1869 the late William Sugg described the London Argand burner, which all readers of this magazine will know was the standard burner for illuminating power until the adoption in 1905 of Mr. C. C. Carpenter's "No. 2 Metropolitan London Argand Burner," and even now the old "London Argand" is in general use.

In the matter of gas illumination for the million, the name of George Bray (who died a short time back) stands out as marking an epoch. Mr. Bray was engaged in the cloth trade in Leeds, and in the course of his occupation had recourse to the use of gas in the preparation of fine faced cloth, and it was through this employment that he turned his attention to the manufacture of gas burners; for many years he only made a nipple burner with steatite tip, tested to consume 1, 2, 3, 4, 5, and 6 cubic feet of gas per hour; these burners had, under the steatite cap, a screen of fine wire gauze, and burned with a good-shaped, steady flame, so much so that the gas supplied to public lamps was very generally paid for at the rate of feet per hour, which these burners were sold to pass, no regulators of any kind being used. In later years Mr. Bray made great advances in the construction of gas burners, especially for street lighting, and pioneered the flat-flame system, which was at its zenith in the early "eighties," when both Sugg and Bray were rivals in the field and the electric light made its first bow for public favour.

(*To be continued.*)

SPECIAL SECTION.

Illumination and Eyesight.

THE last century has seen a great development in our means of producing artificial light, and the progress of the last few years has been exceptionally rapid. We have learnt to turn night into day with an ease undreamed of by our forefathers. This improvement has naturally not been without influence on our mode of life. We are able to utilize the hours of darkness more effectually for pleasure, and the ease with which light can now be produced is also a temptation to work longer than in the past, so that the amount of work carried out by artificial light continually tends to increase.

Simultaneously with this improvement in artificial light we may note the ever-increasing supply of printed matter, and the development of education. Far more books and magazines are read than was formerly the case. Not only do more people find their pleasure in reading, but the increase in the number of excellent textbooks is an indication of a certain tendency to replace oral by written instruction, a matter in which we already differ notably from the great nations of the past.

The net result, therefore, is that we use our eyes more than formerly, and also in a different way. At the same time there is every reason to suppose that the increasing use of artificial light will continue, and it is therefore essential to do all we can to realize the most perfect physiological conditions of illumination. For some time past oculists, inspectors of schools, and the medical profession have been calling attention to this subject, and have almost invariably agreed that the evils referred to were at least partially due to bad illumination.

When we consider that all our impressions of the brightness of surrounding objects—the very basis of illumination—are received through the eyes, and depend upon its physiological peculiarities, the need for the advice and co-operation of the physiologist and oculist is evident.

There are, indeed, a vast number of questions connected with illumination which deserve immediate attention. The most evident defect of present day lighting is, perhaps, insufficient illumination. Prof. Scott and Dr. Kerr (Medical Officer to the L.C.C.) have fixed the minimum permissible illumination in schools at about one candle-foot. Higher illuminations, however, are frequently advocated in America, and it is probable that for reading very fine print, in drawing offices, and for work which is especially trying to the eyes, one candle-foot may be profitably exceeded. In any case it is certain that the degree of illumination met with in offices, reading-rooms, &c., is occasionally so inadequate that reading cannot be accomplished without painful effort, which, in the long run, cannot be without influence on our eyes and general physical well-being.

Yet much remains to be learnt as to the exact order of illumination requisite for special classes of work, and the upper limit, where the illumination becomes strong enough to fatigue and strain the eyes through sheer over-brilliancy is very undecided.

This consideration naturally leads to the mention of one recognized bad feature in modern lighting. Every one is familiar with the disagreeable dazzling effect of very bright sources of light placed so that the rays of light can strike the eye directly. Extreme exposure may seriously injure the eye, and it is highly probable that the constant reception of images of naked glow lamps, plants, &c., on the retina, which is an unfortunate result of our present methods of light, is, in a great measure, responsible for the undoubtedly fatiguing effect of working by artificial light.

The ever-increasing brilliancy of our sources of light, the introduction of high-pressure incandescent gas lights, flame-arcs, and metallic filament lamps, has had the effect of drawing public attention to the question.

Yet here, again, expert physiological advice is needed to determine the order of brightness per unit area which must be considered permissible, and, if possible, to provide us with a ready test by which the injurious character of any installation can be readily recognized.

Certainly the brilliancy of the unshaded arc-lamp, and even of the glow lamp, is far above what is physiologically accepted as safe.

Prof. Basquin has estimated that the average brightness of the sky in the northern part of the United States is in the neighbourhood of 2·5 C.-P. per square inch, and this may perhaps afford some indication of the permissible brightness per unit area of a source of light. Dr. Louis Bell ('The Art of Illumination,' p. 308), reasoning from the brightness of a white surface illuminated by bright daylight, has given 5 C.-P. as the maximum permissible limit, and Dr. Karl Stockhausen has mentioned a result not far removed from this figure (*Zeit. für Beleuchtungswesen*, Oct. 10, 1907). Yet one would like to feel that any such universally accepted determination rested on actual physiological evidence. Possibly the study of the contraction of the pupil orifice, and the "after-image" of the fatigued retina might furnish valuable information on this point.

Violent contrasts of light and shade, and "flickering" sources of light, are also undeniably trying to the eyes, and deserve the authoritative condemnation of the oculist. Again, the use of glossy and highly calendered paper, which reflects the light regularly and directly into the eyes, is believed to lead to bad results, and some have ascribed this to the fact that the light comes from an unusual direction, and so impinges upon a part of the retina which is not usually exposed to light. Whatever the reason, however, there can be no doubt that paper of this description is very trying to the eyes of clerks, book-keepers, and those who are continually bending over shiny-paged books. Dr. Louis Bell, indeed, in commenting on this danger, recently stated that he had been in counting rooms where every clerk bore signs of bad eyes (Proc. Am. Acad. of Arts and Sciences, vol. xliii., No. 4, Sept., 1907, p. 88).

A word or two may next be said on the subject of the physiological action of light of different colours. There is perhaps no question in illumination on which so little authoritative information is available, and on which such divergent views are expressed. Yet the introduction of modern sources of light differing considerably in colour, and our growing control over the spectral composition of illuminants, renders such knowledge very desirable. It is not only that the luminous quality of the light yielded by such sources of light differs. We must remember that in most cases the *visible* light is, unfortunately, but a small fraction of the total radiation of a source, and that even when the colour of the light yielded by two sources appears similar, the nature of the radiation, as a whole, yielded by them may be very different.

The effect of the *visible* rays of different colours, and of the heat rays of great wave length, seems to be very imperfectly understood. Physiologists have told us that the chemical action of light upon the retina becomes more pronounced the shorter the wave-

length, and it has therefore been suggested that the blue and violet rays exert a fatiguing action on the retina, similar to that of the ultra-violet rays, but less pronounced. On the other hand, it has also been frequently maintained that the red end of the spectrum is exciting and irritating, while the blue end is soothing, and there seems to be definite physiological evidence of the existence of a second effect of this nature.

One point on which not the remotest doubt can exist is the dangerous character of the influence on the eye of an excess of ultra-violet energy. This question is the more important because we have now at our command sources of light, such as the Heraeus quartz lamp and the Schott "Uviol" lamp, which are far more powerful in such rays than any known a few years ago. It is even possible that the comparatively small quantity of energy of this description radiated by the sources of light utilized for ordinary purposes of illumination, is not without influence.

Yet very few authoritative data are available as to the practical aspect of these questions, and it remains to be seen to what extent they actually influence our daily life. There is a general and apparently well-grounded impression that artificial light is more trying to the eyes and more fatiguing to the worker than daylight illumination, but how far this is due to the spectrum of artificial light, and how far to the method in which this light is utilized, cannot be said with certainty at present.

Amidst these perplexities, however, one point seems clear. Our eyes have certainly been developed so as to utilize *natural* light—daylight—to the best advantage. Our wisest course would, therefore, seem to be to imitate the spectrum of daylight as closely as possible, and, in the present state of our knowledge, to avoid working for any length of time under any untried light of very peculiar spectral composition.

The differences of opinion expressed points to the need for co-operation on the part of the oculist and the physiologist in order that we may receive definite information as to which features of modern lighting are really seriously injurious, and which are of only secondary importance. As we have seen, there are certain obvious defects of many modern systems of lighting on which there is fairly general agreement, and the recent statements of the medical profession make it clear that they, too, consider the lighting conditions frequently met with very unsatisfactory.

The question has recently received special attention in its application to the lighting of school buildings, and it is a striking fact that those who have investigated this subject have almost invariably commented on the need for improvement in the lighting of school premises.

Prof. Scott reported (*Illum. Engineer* of New York, Oct., 1907) very unfavourably on the lighting of a number of American schools very exhaustively examined by him. He mentions the unsatisfactory eyesight possessed by the children in these schools, and goes on to point out that the daylight and artificial lighting frequently did not come up to a reasonable standard of efficiency. In most of the rooms examined there were dark regions where the illumination did not come up even to the minimum permissible illumination of one candle foot. He concludes :—

> "Because of the lack of attention which is paid to the light actually present in the school-rooms, and because of the great difficulty in adjusting our windows and shades to the varying intensities of the external sources of light, it is not surprising that we should find in our school-rooms conditions of light so bad that during many hours and days reading of ordinary printed matter without undue strain upon the eyes is impossible."

That these remarks are, in some measure at least, applicable to our own schools is shown by some recent remarks of Dr. Kerr, Medical Officer to the Educational Department of the London County Council. In his report for the present year Dr. Kerr likewise lays stress upon the necessity for adequate lighting arrangements, above all in the case of children.

"A normal person of middle age," he says, "will distinguish characters on paper in a poor light with greater readiness than a small child, because the characters are more familiar to the adult, and so much more easily recognized. Conversely a child requires a better light to learn to read by than does an adult, to whom reading is second nature. From a large number of experiments the least illumination permissible on the school-desk of a child has been found to be equal to 10 candle-metres."

He then proceeds to describe methods of securing a satisfactory and uniformly good illumination over school-room desks, and also points out that the children's and teachers' portions of the school-room require separate and special attention, especially the satisfactory illumination of black-boards and diagrams, &c.

The British Medical Journal of 1905, in an article on 'Eyestrain and Brain-strain,' drew attention to the same subject, and quoted the results of Dr. Kerr's previous researches on the lighting of different schools. As a mean of all the figures given it appears that of 163 schools visited, the artificial illumination of 31 (or 20 per cent.) was classed as fair, while 29 (or 18 per cent.) were classed as really bad. The window illumination was less satisfactory, for in 43 schools (or 27 per cent.) it was only considered fair, and 40 (or 25 per cent.) it was bad.

It must be noted, however, that these results were obtained in 1903, and that during the last four years the arrival of illuminating engineering has given rise to a very different standard of illumination, so that the lighting of many buildings, which was then considered adequate, might now be condemned.

The whole question of school-room illumination seems to have come into prominence by reason of the unsatisfactory nature of the recent eyesight returns. The deterioration of the eyesight of children during school life has given cause for grave concern, and that the gravity of this question is not exaggerated the following instances show.

The first investigations on this subject seem to have been undertaken in Germany, probably because this country was one of the earliest to institute a wide educational system, and possibly, too, because the German letters are, admittedly, exceptionally trying to the eyes. We may note, for instance, the investigations of Dr. Herman Cohn, of Breslau, referred to in Prof. Scott's recent article on this subject (reported in American *Illuminating Engineer*, Oct., 1907), that short sight hardly existed in village schools, but became more prevalent with the increasing tax on the eyes entailed by more severe school work, until, of the pupils who remained at school the full fourteen years, 63 per cent. were found to have defective sight. Subsequent investigations have led to similar results. The German Government have been making strenuous efforts to remove the cause of this evil, and it is stated that they now intend to create a commission of architects and engineers to decide how the lighting of school-buildings is to be conducted in future, so that the question will receive attention as new schools are built. (Dr. Wendell Reher, *Transactions* of the Illuminating Engineering Society, Feb., 1907, p. 125.)

The report of Dr. Maximilian Bondi, of Vienna, supplies similar high figures (*British Medical Journal*, February 4th, 1905, p. 258).

Dr. Bondi examined 949 pupils, varying in age from 8 to 19 years. In the Realschule, 22 per cent. of the children in the upper school were short-sighted, but only about half this percentage in the lower school. In the Gymnasium, on the other hand, 31·5 per cent. of the elder pupils were short-sighted, and of the younger 14 per cent.

In America the conditions seem to be likewise unsatisfactory. The Vermont State Legislature began to study the eyesight of children at the schools in 1905. Mr. Lansingh has recently stated that 34 per cent. of these children were found to have defective vision.

In New York, of 58,948 children recently examined, 17,938, or about 30 per cent., are stated to have defective vision (*Illuminating Engineer*, April, 1902, p. 149).

Prof. W. D. Scott (*ref. cit.*) has quoted even higher figures. The circular

issued by the United States Bureau of information in 1881 led to the irresistible conclusion that near-sightedness steadily increased from class to class until, in the highest grades of school attendance, as many as 60 to 70 per cent. of the children had defective vision. Yet, in these tests, children were only regarded as short-sighted if their visual acuity in one or both eyes was $\frac{2}{3}$ or less than that of a normal eye.

One deplorable fact, brought out by more recent investigations, on which Prof. Scott lays stress, is the fact that the children of the present day seem to be becoming short-sighted at an even earlier stage in their school career.

Lastly, some references may be quoted to indicate that the condition of things which is deplored on the Continent and America are, unfortunately, also to be met with in our country.

Attention may be drawn first to some statistics quoted by Miss Sayer, Medical Officer to the London Educational Committee (Int. Congress of School Hygiene, 1904, *B.M.J.*, 1904, vol. i. p. 418).

In the London schools alone there are nearly a million children. At least 25,000 of these were found to be actually seriously handicapped by defective vision. Of children of 6 years of age and under, only 3 per cent. had seriously bad vision, and 88 per cent. perfect sight. But at 11 years of age the percentage of children having really bad sight had risen to 11, while only 58 per cent. had perfect vision. Here, again, the influence of the strain of schoolwork seems clearly traceable.

In the same way Dr. H. Wright Thompson, oculist to the School Board of Glasgow, has stated that of 52,493 children distributed between 67 schools, 35 per cent. were found to have defective vision in one or both eyes (*British Medical Journal*, Sept. 14th, 1907).

Dr. Inglis Pollock, again, found that among the children in certain schools in Glasgow, only 1·7 per cent. of those below 5 years of age had defective vision. This percentage rose steadily until, at 13 years, 8·4 per cent. of the children had defective vision. At 18 years of age 25 per cent. of the pupils were similarly afflicted (*British Medical Journal*, Dec 23rd, 1905).

The situation, indeed, is summed up in an article in *The British Medical Journal* commenting on Dr. Bondi's results (*ref. cit.*) as follows :—

"Investigations in the schools in France, Germany, and in this country put it beyond doubt that the proportion of children suffering from myopia steadily increases as we pass from the lower to the upper classes,"

and attributes these defects to

"young people attempting to do fine work and read badly printed books in ill-lighted schools."

The author has dealt with these figures at some length in order to show that the general recognition of the importance of this evil seems to be well grounded, and that the conditions producing it are clearly not confined to any locality, and are found alike in the schools of the European nations and in America; the question is one of international importance.

The exact nature of these adverse conditions requires further study. It seems to be generally accepted that the main cause of *short sight* is the strain thrown upon the eyes of young children by too much close work.

Prof. Scott points out that our eyes were primarily adapted for distant vision, and that it is only quite recently that we have thrown upon them the constant strain of accommodation for near objects. He explains further that the developing child's eye is exceptionally easily injured by such effort, and advocates that such work as reading and writing should be entirely omitted in the first few years of a child's education.

What, however, we are chiefly anxious to learn is how far bad methods of illumination are responsible for these defects.

The figures here hitherto quoted have referred chiefly to "short sight," and it seems to be generally admitted that poor illumination, by tempting the worker to bring his eyes close to his work in order to make out the print, hastens short sight.

But there is also every reason to suppose that unsatisfactory illumination is very often responsible for the variety of eye troubles classed as "Eyestrain," and that further, the mental effort involved in attempting to work under bad lighting conditions is frequently indirectly responsible for headache, ill-health, and general breakdown. Dr. Kerr, for instance, mentions in his recent report that, in the Paddington Technical School and the Hackney Downs Secondary School, many pupils, quite apart from vision tests, showed signs of eyestrain—headaches, blinking or smarting of the eyes, and the like.

The same authority stated in his evidence before the recent Royal Commission on Physical Degeneration in 1903, that "the real harm of defective vision and schoolwork not adapted to the usual capacity in the young, lies in the strain thrown upon the developing nervous system." Miss Sayer has laid stress on the distinction between defective visual acuity and want of perception by the brain centres among school children (*ref. cit.*) and a number of cases of general ill-health that have been recently described in the columns of *The Lancet* and *The British Medical Journal* which were attributed to the indirect influence of eyestrain.

While, therefore, the present data do not seem sufficient to enable us to state definitely how far the defective eyesight existing is directly traceable to bad illumination, it is contended that the connection is sufficiently evident to emphasize the necessity for close supervision of our present methods of lighting.

We know that the eyesight of school-children—regarding whose sight exceptionally complete data are available—gives cause for grave concern. We know that the illumination of such schools as have been examined has been pronounced unsatisfactory. And there is therefore every reason to advocate a closer investigation of the connexion existing between the two. By a proper study of the scientific principles of illumination we may be able to reduce the troubles mentioned above, to a minimum.

The Sacrifice of the Eyes of School Children.

By Prof. Walter D. Scott,

NORTH-WESTERN UNIVERSITY.

(*From The Popular Science Monthly.*)

In the evolution of the animal organism the sense of touch has served the purpose of informing the individual of objects with which it came in contact. The sense of taste likewise gave information concerning objects upon contact, but of a more specialized form. The sense of smell and that of hearing gave knowledge of objects in the vicinity, and in certain instances of objects in the distance. The sense of sight seems to have been pre-eminently the sense by means of which the individual was enabled to adjust himself to objects at a distance. The enemy to the leeward might approach noiselessly, and so could not be smelt or heard. When knowledge of approach was revealed by the sense of touch it was too late for escape. The preservation of the individual and of the species thus depended upon the ability to see the enemy in the distance. Inasmuch as the function of the eyes has been to perceive objects at a distance rather than at close range, we are not at all surprised to find that the eyes are well adapted for distant vision, but poorly constructed for close work.

When our eyes are at perfect rest, when all the muscles which control them are relaxed, they are then adjusted for distant vision. When, on the other hand, the ciliary muscles and the muscles which move the eyeballs are at a maximum of contraction, then and then only are the eyes adjusted for close vision. Such a structure was admirably adapted to the needs of the primitive organism. The eyes were the sentinels which must always be on guard, and when employed in the appropriate way there was no strain. It was, of course, essential that the individual should be able at times to see objects close at hand. This could be accomplished by means of contractions of delicate muscles, and as soon as the contractions were relieved the eyes were again adjusted for the more important duty of distant vision.

The strain upon the eyes is in adjusting for objects closer than at about four feet, but for all greater distances there is a minimum of strain. Hence we may speak of all objects as being *distant* which are removed as much as four feet. With this definition of the term distant it is evident that distant vision was the most common form of vision for all our ancestors, from the most primitive forms of life to the most highly civilized races, till the last few centuries. With the invention of writing, and then with the invention of the printing-press, a new element was introduced, and one evidently not provided for by the process of evolution. The human eye which had been evolved for distant vision is being forced to perform a new part, one for which it had not been evolved and for which it is poorly adapted. The difficulty is being daily augmented. The invention of printing-presses has been followed by an increasing number of books, magazines, and daily papers. The rural population has given place to the urban. The long days of manual labour have given way to the eight-hour system with abundant time for reading. Labour-saving devices of all sorts have added to our sedentary habits. All things seem to be conspiring to make us use our eyes more and more for the very thing for which they are the most poorly adapted. It requires no prophet to foresee that such a perversion in the use of an organ will surely result in a great sacrifice of energy, if not of health and of general efficiency.

The Amount of Light required for Reading.

The eye has thus far been spoken of as though it consisted merely of delicate muscles, when in reality these are not the most significant part of it. In thinking of the eye we should never disregard the eye-muscles, but primarily the eye is a live camera, consisting of a lens, dark-box, and sensitive plate. The retina in the back part of the eyeball is the sensitive plate, and is the most vital part of the eye. It is affected by every ray of light falling upon it. Fortunately it responds to a weak light, and still is not injured by a moderately strong one. In speaking of the quantity of light it is well to have a standard. For this pur-

pose the most convenient standard is the amount of light cast by a standard candle upon any point in the horizontal direction one foot from the candle. A light of twice this intensity is spoken of as a two-candle power, a light ten times the first is of course a ten-candle power. The light cast by a candle upon a printed page at a distance of one foot is sufficient for legibility at the normal reading distance. If the light is less than this the retina is not adequately stimulated and the reading is accomplished only after a strain more or less intense. If the light falling upon the page exceeds ten candle-power the stimulation of the retina is so great that it is displeasing to some people and is condemned by our best authorities as injurious to the retina. All are agreed that less than a single candle-power is injurious for reading, and during the present state of our knowledge it is at least safe to avoid an illumination of more than ten candle-power.

The iris may be blue, brown, or grey, and is that which determines the colour of our eyes. It is an adjustable shutter which reflexly regulates the amount of light which enters the eye. In the presence of a bright light the iris diaphragm contracts, reducing the size of the pupil, and cutting out much of the light which would otherwise enter the eye. In the presence of a dull light the pupil enlarges, allowing a great amount of the light, such as that falling upon a book, to enter the eye and to stimulate the retina. The iris is a wonderful device, but cannot in diverse illuminations perfectly equalize the amount of light entering the eye. The pupil expands inversely as the square root of the illumination. Thus if the actual illumination of the book increases ten-fold, the amount of light falling upon the retina is increased but little over three-fold. Even a twenty-five candle light sends but five-fold as much light into the eye as a single candle-power. A single candle-power seems sufficient, and ten candle-power is not too much. This ability of the retina and of the iris to deal successfully with lights of such different intensities is a most useful and necessary characteristic. Unfortunately, however, the actual diversities of intensities of lights used for reading are far beyond any for which the eye can adapt itself.

Variations in the Amount of Daylight.

We are in the habit of thinking of the light received from the sky—the daylight—as almost a fixed quantity during the hours from 9 in the morning till about 4 in the afternoon. The darkness preceding a storm and the occasional dark days are of course not forgotten, but, in general, daylight for the hours mentioned is thought of as at least fairly constant. To test this point observations were made at 9 A.M., 12.30 P.M., and 4.30 P.M., daily for five and a half days a week for twenty-two months. These tests were made in the Chicago laboratory of the American Luxfer Prism Co., and under the direction of Prof. Olin H. Basquin, of the Department of Physics of North-Western University. Inasmuch as the amount of sunshine and general illumination in Chicago is almost exactly the average for the United States, these results may be regarded as typical for the whole country, with the exception of such dark cities as Seattle or such light ones as Phœnix. Measurements were made of the amount of light coming through a square foot of clear glass placed horizontally in the roof of the observation building. The illuminometer was placed so far below the opening in the ceiling that the direct rays of the sun could never reach any part of the recording apparatus. The light thus measured was diffuse daylight received from the zenith of the sky. Taking the average illumination for the twenty-two months at 12.30 as the standard, it was found that the illumination at 9 A.M. was but 67 per cent. as great as that of mid-day. Again the illumination at 4.30 P.M. was but 27 per cent. as great as that at 12.30. Expressed in other terms, we see that the available light at 4.30 is approximately but one-fourth that of noon, and the light at 9 o'clock but two-thirds that of noon. These figures are the average for the school days of twenty-two months in one city, and although observations for a longer period and in other cities might change the results somewhat, it is safe to assume that our figures are not far from the actual conditions in a majority of our schoolrooms in the United States. In general a room which is barely adequately lighted at 12.30 will be 33 per cent. under-illuminated at 9 o'clock, and at 4 o'clock its illumination will be but 27 per cent. of the necessary amount.

Our difficulties are further complicated by the fact that the variations in illumination of daylight are as great between the months of the school year as between the hours of the school day. The illumination is best in the months of June, July, August, and September. Then follow in order May, April, March, October, February, November, January, and lastly December. Comparing the illumination

of the four bright months (June, July, August, and September) with the four dark months (November, December, January, and February) we find that for the twenty-two months observed the illumination of the dark months is but 28 per cent. of that of the bright ones. This figure is found by averaging the three daily readings for each day for all the months concerned. December, the darkest month, has but 18 per cent. as great illumination as June, the brightest month.

When to these variations as between months or seasons we add the variations between mid-day and morning and evening, the results are most astounding. The light at noonday in June averages almost tenfold as much as that at 9 A.M. in December. If it is injurious to read with a light less than one or more than ten candle-power, a schoolroom that furnishes this maximum in June will be reduced to the minimum in December mornings and evenings on average days. Such deviations in the external source of light put most restricting conditions upon school architecture. How have we met the conditions, and how might we construct our schoolrooms to meet the situation satisfactorily ?

Rules for Lighting a Schoolroom.

In our climate it is almost impossible to over-light a schoolroom if the two following conditions are observed: (1) Never allow the direct rays of the sun to fall upon any surface within the field of vision of any pupil. (2) Avoid all glossy or shiny surfaces which reflect the light directly into the eyes of the pupils. A dead white surface is not injurious, while a darker surface may be shiny and hence injurious.

For securing adequate light the following rules are important: (1) The window space should be as much as one-fifth of the total floor space, and the height of the window two-thirds of the width of the room. (2) The walls, ceiling, woodwork, furniture, &c., should be a colour which reflects a large amount of well-diffused light. Perhaps the best colours for this purpose, in the order of their efficiency, are white, light yellow, light grey, light green, light blue, and light pink. (3) The schoolroom should be narrow and the windows facing an unobstructed area, so that from any seat in the room a large amount of sky is visible. (4) The windows should be provided with white holland screens, or others of a similar sort, which obstruct the direct rays of the sun, but which, when drawn down, emit into the room a maximum of diffused light. (5) There should be at hand light-coloured curtains which may be used to cover up all black-boards as soon as the darker parts of the room are inadequately lighted.

It is apparent to all that the construction of our schoolrooms has not conformed to these five simple rules. There are many rooms in which the window space is one-fifth of the floor space, but certainly not a majority of all schoolrooms in America. The second rule, concerning the reflecting surfaces within the schoolroom, is broken by the extensive surfaces of black-boards and by the dingy colour of the walls. Walls soon fade and become dirty, and need frequent attention to keep their reflecting power approximately at its maximum. The third rule is broken by constructing rooms so large that they will accommodate fifty pupils, and by placing school buildings too close to adjoining buildings. The fourth rule is broken by the use of opaque shades, which, when drawn to escape the brilliancy of the sun, leave the room darker than it would otherwise be on a dark and cloudy day. Because of this fact the schoolrooms with a southern exposure are perhaps our most poorly lighted rooms. The fifth rule, concerning the use of white screens for the black-boards, is never observed, and to many may seem insignificant. The justification of the rule is found in the following facts.

Dark Corners in Schoolrooms.

The ordinary schoolroom has the light from one side. The five rows of desks are so arranged that one row is next to the windows, and the last row next to the black-board on the side of the room opposite the windows. It is well known that the desks next to the black-board and furthest from the windows receive less light than the desks next the windows. That the difference between the first and fifth rows is great enough to occasion any alarm seems not to have been suspected. In the ordinary schoolroom the light reflected from the pupil's book on the first row is eight times as great as the light reflected from the book of the pupil who is so unfortunate as to sit in the row next to the black-board. The decrease of the light as the distance from the window increases is different in each room. The law of the square of the distance is not even approximately correct, but it is safe to say that in the great majority of schoolrooms in the United States the row of desks next to the windows has many-fold more light than the rows next the black-boards. Prof. Basquin and I tested schoolrooms

having windows on but one side. In these rooms the variation between the first and fifth rows was from seven-fold to ten-fold. By the introduction of screens over the black-boards in the same rooms, the light at the darkest seat was increased as much as 50 per cent. That an increase of 50 per cent. in the light in the dark corners of our schoolrooms is important is apparent to all. Furthermore, this result can be secured with little or no cost. Most schools possess white screens, light-coloured advertising maps, charts printed on white paper, &c. They may be used to cover the black-boards, and when thus used they will reflect the light to the very parts of the rooms which need it most.

Because of the lack of attention which is paid to the light actually present in the schoolroom, and because of the great difficulty in adjusting our windows and shades to the varying intensities of the external source of light, it is not surprising that we should find in our schoolrooms conditions of light so bad that during many hours and days the reading of ordinary printed matter without undue strain upon the eyes is impossible.

Unwise Demands made upon the Eyes of Young Children.

Until within a very few decades reading was taught by a slow and cumbrous method. The effort of reading was so great that few children enjoyed the reading of a book until after they had completed the third school year. Interesting books for children were few in number and not available for the vast majority of them. To-day this is all changed. Our methods of teaching reading are so improved that before the child has been in school a full year he begins to read books at home for his own pleasure. Our printing-presses are teeming with children's books. Andrew Carnegie, or rather the movement which he so ably supports, has filled city and country with free books available for even the youngest. During the last twelve months I have tested the eyes of some 700 children. I have asked of each child an estmate of the number of books read in the preceding twelve months. One room of 31 pupils for the twelve months preceding the middle of the second school year, gave the following figures. The average number of books read by each pupil was 22. Some had read but few, while others had read many more than 22. One-half of the pupils had read 20 books or more. It should be observed that this record of the number of books covers the period from the middle of the first school year to the middle of the second school year. After the second school year many pupils read regularly a book a week. In several of the grade rooms tested, the pupils of the room read on the average as many as 50 books a year. In the first three years after reaching the legal school age not a few pupils in our best city schools read 100 books. This figure is certainly far above the average, but there is a tendency to increase the number of books read during these first three years of school. We should but deprecate the tendency, and do all we can to stop it. During these three years the pupils are growing faster than during the following years. At this time there is a decrease in the nervous energy of the child. In recent studies of the order of development of motor adjustments and co-ordinations, it has been found that the individual first acquires control over the larger muscles and later over the finer ones. The normal activity of the child exercises mainly the larger muscles. The plays of children give the widest scope to the exercises of such muscles. The coarser movements are most predominant. while the finer adjustments and the use of the smaller muscles are of secondary importance.

By our improved forms of modern education all this is changed. We put the six-year-old child to the task of reading and writing. These acts involve the use of the smaller muscles of the organism, and are dependent upon more exact control of these muscles than any other act the individual is ever likely to be called upon to execute in later life. If an adult is out of practise in the use of the pen, a single hour's work is sufficient to exhaust the hand. The extreme exertion which the child puts forth to guide the pen or to follow line upon line with the eyes is so far in excess of the amount of energy required by an adult that we are not in a position to appreciate the severity of the child's task. Children upon entering school have better control of movements involving the whole arm and the wrist than of those involving the wrist and fingers. The muscular control of the eyes is adequate for all free movements of the eyes, but not sufficient to warrant the finer adjustments of continuous reading. The loss of nervous energy, necessitated by reading and writing, at the ages of from five to eight years is an unwarranted drain upon the health of the child. At this age the child needs free and vigorous movements rather than the constrained and finer ones required in reading and writing. At

a later age the control over the finer muscles is adequate for the task, but in this age of rush we are crowding our little ones and inverting the order of nature. Furthermore, the tissues of the globes of the eyes are still soft, and the strain of the ciliary and other eye muscles is likely to cause short-sightedness by increasing the anterior-posterior axis of the eyeballs. If the child's eyes do thus lengthen under the excessive strain, the eyes are not only weakened for vision, but they become diseased organs.

We have thus far attempted to establish the following four propositions. (1) The human eye was evolved for distant vision, and the perversion incident to reading and writing would lead us to expect some great injury to the organism. (2) Although the eye may easily adjust itself to a light changing from one to ten candle-power, the diversities of daylight during the hours of the school day and the months of the school year are so great that the minimum and maximum extremes are frequently exceeded. (3) The necessary rules for lighting buildings are not adhered to, thus placing an unnecessary strain upon the eyes of all attempting to read and write. (4) There is a growing tendency to use the eyes at a period of life which is in every way ill fitted to the task. If these four propositions had been established, and if the pessimistic forebodings are justified, then investigations of the eyes should discover a general destruction of the eyes of civilized countries, and an increasing number of eyes injured during the age of from six to nine.

Investigating the Eyes of School Children.

Systematic investigations of eyes upon a wide scale were not begun till 1865. At that date Dr. Herman Cohn commenced his investigations of the eyes of school children in Breslau. After having examined ten thousand children, he summarized his results as follows:—

Short-sightedness hardly exists in the village schools; the number of cases increases steadily with the increasing demands which the schools make upon the eyes, and reaches the highest point in the gymnasia.

The number of short-sighted scholars rises regularly from the lowest to the highest classes in all institutions.

The average degree of myopia increases from class to class, that is, the short-sighted become more so.

The circular of information of the United States Bureau of Information, No. 6, 1881, in speaking of the many investigations which had been made in this and other countries, said: —

All, without a single exception, prove beyond a doubt that near-sightedness, beginning, perhaps, at nothing in the lower classes in the school and first year of school life, steadily increases from class to class in the school until in the highest grades or in the last years of school attendance it has actually developed itself in as many as 60 or 70 per cent. of all the pupils.

In all these tests children were not regarded as near-sighted unless their visual acuity in one or both eyes was but two-thirds of normal vision or less. Think of the significance of these statements, which are entirely authoritative. Pupils entering our schools come to us with good eyes, but if they stay with us till the end of the course, 60 to 70 per cent. of them will leave us with but two-thirds normal visual acuity or less. Most of this loss of vision is caused directly by the strain put upon the eyes in reading, writing, and drawing.

The Sacrifices Caused by Premature Strain.

The picture drawn by the investigators during the two decades following 1865 was dark indeed. The only ray of hope was found in the fact that the destruction of the eyes did not begin during the first few years of school, so that pupils dropping out before the eighth or tenth year would probably escape with good eyes. Thus Cohn found that in the case of pupils eight and a half years old there were but 5 per cent. myopic, while of the pupils remaining the full fourteen years, 63·6 per cent. were myopic. Investigations of the pupils of other cities of Germany resulted in similar findings. Investigations in America were not so numerous as those in Germany, but in general the results were the same until recent years.

Investigations carried on in Worcester, Massachusetts, in 1891, showed that in the second and third grades from 50 to 60 per cent. of the pupils possessed less than normal visual acuity. Investigations upon over 3,700 pupils of the Chicago public schools, in 1899, showed that the maximum of defective eyes was reached with pupils nine years old. No one seems to have remarked upon this change in the grade at which the maximum destruction of the eyes is found. In fact, the results seemed to have been looked upon as rather accidental and of no special significance.

Some months ago I asked myself these two questions. Is the maximum destruction of the eyes of the school children reached earlier than formerly ? Secondly, if such is the case, what is the cause of it ? In attempting to answer these questions I have tried to learn what recent investigators have found concerning eyes, and I have attempted personally to examine the eyes of children in schools which were significant. The data which I have secured lead me to conclude that the excessive destruction of the eyes begins several years earlier than was formerly the case in America, and earlier than is still the case in Germany and other foreign countries. As to the cause of the early injury of the eyes the results of my investigations are most significant. The highest per cent. of defective visual acuity I have thus far discovered was found in a room in which the pupils had been in school but one and a half years. This is the room referred to above, in which the average number of books read by each pupil during the preceding twelve months was twenty-two. It may not surprise you when I tell you that 84 per cent. of these little innocents had defective vision. The schoolroom in which they were seated was unusually well provided with windows and had a south exposure. Unfortunately their teacher preferred a rather dimly lighted room, and made generous use of opaque shades with which the windows were provided. The light by which the pupils read in school was in most cases certainly better than the light which they had for their reading of books at home. Some of these children in their childish ignorance took books to bed with them, and upon awakening in the morning read before breakfast. It is probable that in most cases the children at home read during the evening twilight till it was too dark to tell one word from another. Then they would retire to some dark corner of a dimly lighted room and continue the reading till supper-time or bedtime. Young children have no regard for their eyes, and parents are not likely to interfere with them as long as they are quiet.

The pessimistic forebodings expressed in the first part of this article are more than justified by the figures just presented. The eyes of our school children are being destroyed, and worse than that, the destruction is now taking place at the age of from seven to nine years, which makes the matter so serious that we should bestir ourselves to lessen the evil as far as possible. In the palmy days of Greece the Athenian boy was not taught to read till he was ten years old. By our modern improved form of education we injure the eyes of our children so that one-half of them have defective vision before the age at which the Greek boy learned his alphabet.

The gravity of the situation is so great that I venture to offer in conclusion the following suggestions :—

1. We should recognize the fact that human eyes are ill adapted for reading, writing, and drawing for a long period at a time.

2. We should recognize the fact that the normal daily deviation of daylight is so great that any method of adjusting the window shades from mere habit is inadequate.

3. In constructing schoolhouses the window space should be as large as that described above.

4. The interior walls and ceilings should be light.

5. The amount of sky visible from each seat should be large.

6. The windows should be provided with white holland screens or their equivalents.

7. Every schoolroom should be provided with light shades, and they should be placed over the black-boards as soon as there are dark corners in the room.

8. School children's eyes should be tested annually, and parents notified that an oculist should be employed in the case of all defective eyes.

9. Children should not be taught even the elements of reading or writing during the first year of school. For the ordinary reading and writing should be substituted more oral instruction in language, number work, nature study, history, singings physical training, play, and other form, of training suited to the needs of the pupil.

How are we to Protect our Eyes from the Ultra-Violet Rays yielded by Artificial Sources of Light?

By Dr. Fritz Schanz (*Oculist*) and Dr. Carl Stockhausen (*Engineer*).

(Abstracted from the *Zeitschrift für Beleuchtungswesen*, Oct. 10, 1907.)

Dr. Schanz refers to the experience of his collaborator (Dr. Stockhausen), who experienced severe inflammation of the eyes after working with an electric arc lamp. Many experiments have proved that this effect is caused by the ultra-violet rays. These rays are invisible to the human eye, but produce powerful chemical effects, and are easily recognizable by their action on a photographic plate.

Hitherto a glass plate, placed between the eyes of the observer and the source, has been considered adequate protection, but this did not suffice in the case to which reference has been made. Dr. Stockhausen wore his spectacles while making these experiments, but nevertheless suffered severely. This circumstance induced the authors to undertake an investigation, with the object of determining to what extent glass really does absorb ultra-violet rays. It was found that the usual glass lamp-shade and the glass used in spectacles only absorbs rays of shorter wave-length than about 300 $\mu\mu$, and these are known to be just those rays which possess the least "penetrating power," and are, therefore, least deep-seated in their action on the human organism.

The most powerfully active rays are those between 300 and 400 $\mu\mu$, and these are transmitted by the glasses referred to. The so-called "blue" glasses, in fact, so far from affording additional protection, allow these rays to pass through with special ease. Smoked glasses weaken these rays, just as they do the visible spectrum, without completely suppressing them, however.

The authors have also investigated the richness in ultra-violet rays of many artificial sources of light, ranging from the torch-light and oil-lamp to the new quartz-glass mercury lamp. Briefly, the intensity of the ultra-violet element became more and more marked with rising temperature. Yet no general attempt has been made to suppress these rays, which are quite useless from the point of view of illumination.

Every one must have noticed how quickly the eyes tire when we attempt to execute a piece of work by artificial light, which we are only just able to get through in daylight. The light "strains" the eyes. When the eyes are already subject to a slight inflammation, the effect is more marked still.

Diffused sunlight is not very rich in ultra-violet rays, because our atmosphere absorbs them very markedly, and also because a very large proportion of such light is lost by multiple reflection, before the light reaches our work-table and eventually our eyes.

There is a piece of apparatus in the eye which protects the retina from the influence of ultra-violet rays, namely the lens. When strongly illuminated by ultra-violet rays, the lens becomes fluorescent. The ultra-violet light has, therefore, been converted into visible light.

This naturally raises the question whether the energy continually striking the eye may not, in time, effect appreciable alterations in the organ.

Widmark, Schuleck, and other workers have detected a cloudy formation in the lens under the influence of ultra-violet rays.

The authors therefore suggest that the various forms of cataract might be initiated in this way. It is not easy to prove, definitely, that this cloudiness of the lens of the eye is more prevalent than previously, when we had no sources of light which were rich in ultra-violet rays. Yet this possibility must be borne in mind.

We ought, therefore, to seek to protect our eyes from ultra-violet light, not only because of its irritating effect on the anterior portions of the eye, but also because of the possibility that the cataract of old age may be appreciably accelerated thereby.

It is desirable, therefore, to utilize a variety of glass which absorbs these rays more completely than the glass in general use.

The authors have succeeded in producing such a glass, which they hope will be put on the market very shortly.

The Illumination of Work-places and Workrooms.

By Dr. Karl Stockhausen.

(From the *Zeitschrift für Beleuchtungswesen*, Oct. 10, 1907.)

Dr. Stockhausen remarked that a distinction must be drawn between the influence of the visible and the invisible rays upon the eye. But the dazzling effect of visible light of too great intensity is also injurious. From a hygienic point of view the brightness per unit area of an illuminant should not, the author thinks, exceed 0·75 candle-power (Hefner) per square centimetre of radiating surface.

The author traces the continually increasing surface brightness of modern illuminants, and compiles a table giving details of forty different sources of light, ranging from the ancient pine-torches and oil-lamps up to the inverted incandescent mantles and the newest metallic-filament glow-lamps of the present day. With the exception of the torches, candles, open oil-lamps, and flat-flame gas-flames, all these sources exceed the limit mentioned above, and should therefore be enclosed in suitable diffusing globes and reflectors.

The continually increasing brightness per unit area of gas-lights reaches a maximum in the acetylene flame and the inverted gas-burner.

The new metallic-filament lamps, and especially the Nernst lamp, with a surface-brightness of 460 c.-p. per square centimetre, are examples of a similar tendency in glow-lamp manufacture.

The brightness per unit area of the petroleum lamp is five times the safe value, and, similarly, the surface-brightness of the incandescent gas-light is eight times, the carbon-filament glow-lamp about 100 times, the metallic glow-lamp up to 270 times, and the Nernst lamp may be as high as 550 times the above value. Worst of all is the electric arc, the brightness per unit area of which is no less than 4,000 times that which the hygienic aspects of illumination demand.

The fact is emphasized, therefore, that all such sources of light, when intended for the illumination of workrooms, ought to be screened by the use of more or less dense diffusing shades. The most satisfactory system of all would seem to be inverted lighting, for in this case the dazzling effects are avoided, and the injurious ultra-violet rays are, for the most part, absorbed by successive reflection from the walls and ceiling.

The author points out, further, that, owing to the faulty construction and use of diffusing globes, brightly illuminated spots are often met with which exceed the permissible brightness per unit area by two to three times.

Finally, he remarks that, during the competition between gas and electricity for lighting purposes, it has become customary to aim at mere brilliancy of illumination, and either to omit the requisite diffusing shades entirely, or to place them in such a way as to throw the light downwards, instead of screening the eyes of the worker.

The author closes his paper with the following recommendations :—

1. All sources of light should be screened by diffusing shades, placed in such a position that the eye is unable to perceive any light-radiating surface of a brightness exceeding 0·75 C.-P. per square centimetre.

2. Chimneys or globes should be made of some variety of glass which absorbs ultra-violet light.

3. Globes must be sufficiently dense, and constructed in such a way as to enclose the source, and to present an evenly and weakly illuminated surface to the eye.

4. Glow-lamps with clear globes should be rejected for the illumination of schoolrooms and workrooms.

5. Inverted illumination is preferable (from a hygienic standpoint) to all other methods of illumination.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

Coefficients of Diffuse Reflection.

By Dr. Louis Bell.

(*The Transactions of the Illuminating Engineering Society, "Convention Issue," October,* 1907.)

In all problems which have to do with practical indoor lighting, the coefficient of diffuse reflection of the walls plays an important part. In lighting such as we have here in the convention room, the coefficient of diffuse reflection is the permanent factor in determining whether the lighting shall be good or bad; and in all cases there is the more or less uncertain factor of wall reflection with which we have to deal.

It, therefore, seems desirable to add somewhat to the meagre data which are at the disposal of the illuminating engineer by measuring the coefficient of diffuse reflection of wall finishes, chiefly papers, in various colours, both by daylight illumination and by illumination from incandescent lamps. The coefficients of diffuse reflection, of course, vary both according to the colour of the finish and according to the colour of the incident light, the two mutually intersecting. I, therefore, started to determine a series of coefficients of diffuse reflection varying both these conditions.

The material was chiefly wall-paper of various finishes and of various colours. The method adopted was to compare each sample with a piece of white cardboard, taken merely for the purpose of a working standard, using the Munsell photometer for the purpose. This photometer gives fairly consistent readings, with a reasonable degree of accuracy, subject only to the condition which affects all photometers, that surfaces of widely different colours are somewhat difficult to compare. Then the coefficient of the standard cardboard which had served for reference, was determined in absolute measure by comparing the incident and the reflected flux of light.

The results of this comparison I have expressed in the accompanying table. The sum and substance of the matter is this: that nearly all the colours, certainly all the strong colours, give somewhat lower coefficients than we have been tempted at times to estimate for them. The absolute coefficient of the standard cardboard was ·74. The highest coefficient obtained with any wall paper was ·64, and that was with a very light cream tint, scarcely perceptibly different from white. That gave a coefficient of ·64 with the incandescent lamp, and ·53 with diffused daylight from a north window and a clear sky, which was the uniform condition under which the daylight measurements were made. The coefficients of the various colours, which ranged all the way from those nearly white in tint to deep greens and deep reds, ranged downwards from ·64 to ·05, the latter figure applying to dark greens and dark reds.

The various results from the papers divide themselves somewhat as follows: Far and away the best, incomparably better than any of the deeply coloured finishes, came the very light creams and yellows. These have coefficients of the order of magnitude of ·4 to ·6; next come the medium papers of grey, yellow, bright red, very light red, pink, and lilac. The coefficients of these run roughly from ·20 to ·40. Finally, last in the line, come some of the present fashionable papers in dark tones, which run down from say ·15 to ·05, winding up with the deep reds and deep greens, which are nearly equally bad.

As respects the differences existing between the coefficients for sky light and those for incandescent electric light, in most cases the incandescent lamp gives a little less satisfactory coefficient by a few per cent. In a few instances, and

specially in the light creams and very light yellows, the reverse is the case, these showing up distinctly better by incandescent lamp light than by the light of the north sky, which is strongly bluish.

A particular point of interest is the very deceptive character of some apparently light finishes, greys in particular, and what the decorators are pleased to call "warm" greys more especially. These colours kill the light in a way that is perfectly astonishing to one who is not familiar with them. The coefficients, for example, for a light grey green drop to a little over 20 per cent. in either light, and the light brownish greys are similarly bad. Grey generally contains a more or less strong mixture of black, and frequently a little tint of red; both of these tend to destroy its colour-reflecting value.

As between the textures of the papers, except for the silk finishes, which in certain directions tend to absorb light very strongly, there seems to be very little difference, the crepe, the cartridge, and plain papers of similar colours having coefficients which are remarkably similar.

A few experiments were made with striped papers, and the difference between the several stripes of the papers found in practice was, as a rule, remarkably small.

TABLE OF COEFFICIENTS OF DIFFUSE REFLECTION.

Kind.	Colour.	Coefficients for Skylight.	Coefficients for Inc. lamps.	Remarks.
Plain Ceiling	Faint Greenish	·50	·53	
,, ,,	Light Ecru	·27	·26	
,, ,,	Very Faint Grey Cream	·53	·64	
,, ,,	Light Grey Green	·26	·23	
,, ,,	Light Yellow	·53	·49	
,, ,,	Faint Ecru	·47	·55	
,, ,,	Faint Pinkish	·41	·43	
,, ,,	Pale Bluish White	·42	·31	
Crepe	Medium Green	·25	·19	
,,	Darkish Coffee Brown	·08	·06	
,,	Deep Green	·05	·06	
,,	Deep Yellow Buff	·41	·41	
,,	Full Green	·06	·06	
,,	Deep Red	·05	·05	
,,	Medium Red	·06	·08	
Cartridge	Medium Green	·15	·11	
,,	Dull Green	·11	·07	
,,	Dull Yellowish Green	·09	·07	
,,	Light Pinkish Brown	·21	·26	
,,	Light Green	·23	·18	
,,	Light Blue	·21	·20	
,,	Pale Grey	·35	·27	
,,	Faint Yellowish Green Grey	·43	·33	
,,	Salmon Buff	·31	·33	
,,	Medium Light Buff	·44	·44	
,,	Medium Full Green	·11	·07	
,,	Medium Dull Red	·06	·07	Grey Red
,,	Light Red	·10	·10	
,,	Very Deep Ecru	·18	·15	
,,	Pale Pink	·25	·19	
,,	Deep Yellow Grey	·18	·15	
Silky Finish	Medium Crimson	·08	·12	Across Grain
,, ,,	Medium Grey Green	·17	·12	
Stripes	Deep Cream	·56	·60	
,,	Deep Cream Silvery	·56	·57	
,,	Yellow Medium	·50	·53	
,,	Deep Buff	·53	·58	
,,	Medium Red	·06	·08	

Kind.	Colour.	Coefficients for Skylight.	Inc. lamps.	Remarks.
Stripes	Medium Red Satin	·07	·11	
,,	Light Strawberry Pink	·43	·43	
,,	Light Strawberry Silvery	·51	·49	
,,	Light and Dark Green	·06	·07	Heavily streaked deep green
,,	Silvery Light Green	·13	·14	
,,	Light Green	·36	·26	Plain
,,	Silvery Light Green	·36	·23	Corded
Miscellaneous	Dark Green and Gold	·24	·19	Minute figuring with much gold
,,	Light Green and Gold	·31	·28	
,,	Deep and Light Red	·12	·20	
Pique	Light Bluish	·46	·47	
,,	Light Grey	·38	·38	

In closing I should say that these figures, so far as lights are concerned, refer to light from the north sky on the one hand and light from the ordinary incandescent electric lamp on the other hand.

As regards the angles of incidence, which are a very important feature in determining the coefficients of diffused reflection, in all cases the figures apply to medium angles of incidence, say from 35 degrees to 45 degrees. They do not apply in any sense to grazing incidence, but they will be approximately true for the moderate angles.

It would be almost impossible, even if it were desirable, to make a detailed investigation of the angular distribution of coefficients of reflection for a large series of papers. It would not be sufficiently instructive, even if made, and these figures will be sufficient to give a fairly clear idea as to the coefficients found with the finishes which are in common use and of which the coefficients do not always bear their values on the face of the paper. The data are for diffusion from a surface where there are no questions of either grazing incidence or grazing reflection coming in, and where there is no element of specular reflection.

Primary, Secondary, and Working Standards of Light.

By Edward P. Hyde.

Taken from *Transactions* of the Illuminating Engineering Society, October, 1907, "Convention Issue."

We are living in an age of exact measurement. With what profound wonder would our forefathers have contemplated the marvellous precision of modern physical science. We compare resistances to parts in a million, we weigh weights to parts in a billion: indeed, if it were not for photometry and a few kindred sciences, I am afraid that the term "per cent.," which for so many years has been the common unit in expressing accuracy, would soon become obsolete in that sense.

What, we ask ourselves, is the cause of this tardy development of photometry? Is it because our instruments are insufficient, or our standards inadequate, or is there some inherent difficulty that cannot be overcome? To be sure we shall always have the limitations of the human eye to contend with, because "light" by definition is subjective, but oftentimes the eye is made the scapegoat for faulty methods or inaccurate measurements. The accuracy of comparison of two luminous sources of the same colour is well beyond that with which the intensity of either can be expressed in terms of our standards. The fault then lies ultimately with our standards.

It is not my intention in this paper to present to you a history of primary standards of light, or to make a study of the relative merits of the various standards in use at present. It is my purpose, rather, to ask your consideration of a few very practical questions in connexion with the relationship of primary, secondary, and working standards of light. By a "primary" standard is meant any standard that can be set up from written specifications, such as the Violle platinum standard, or the Hefner lamp, or the Vernon-Harcourt pentane lamp. By a "secondary" standard is meant a standard which, though not reproducible, will remain constant after having once been calibrated. The well-seasoned incandescent lamp is the best example of this. By a "working" standard is meant any lamp that is used as a standard in ordinary photometric measurements. It may be a secondary standard or even a primary standard, but it is not necessarily either. Though the three classes of standards are quite separate in principle, they overlap in practice.

There is one quality which all standards must possess in common. They must have a suitable colour. This requirement is very indefinite, but it must needs be so. We cannot specify the actual spectral distribution, but we can exclude monochromatic sources. In other words, we can immediately eliminate some sources as being impracticable, whereas we cannot assign values of relative merit to those which fall within the wide range of acceptability. In addition to this common property there are special properties which each class of standards must possess.

A primary standard is good or bad accordingly as it is or is not reproducible. Its fitness as a primary standard depends upon the degree of accuracy with which it can be reproduced. It is not necessary that it should remain constant over a long period of use; the time at which the measurements are to be made can be specified, as is done in the case of the Violle platinum standard. It is not even necessary that it should be particularly inexpensive or simple, as it is sufficient that it should be set up from time to time in one or several of the various national standardizing laboratories now in existence. The only absolutely necessary qualification of a primary standard is, that in case all the secondary and working standards should be destroyed, the unit could be re-established. Of course if a lamp can at the same time serve as a primary standard and also as a secondary or working standard, it is the more valuable. If it is simple and inexpensive, so much the better, but these are not necessary qualities of a primary standard.

In a secondary standard we desire other qualities. These are best seen by keeping in mind an example—the well-seasoned incandescent lamp. A secondary standard need not be reproducible—we cannot make two incandescent lamps exactly alike; but it

must remain constant after having once been calibrated in terms of the primary standard. It should be portable, simple, and inexpensive. Every standardizing laboratory should have a number of secondary standards against which to measure the working standards of lamp manufacturers and testing laboratories.

The working standards should be adapted to the particular kind of testing in which they are to be used. In testing incandescent lamps, we want as working standards other incandescent lamps; in testing gas or oil, we want flame standards. Working standards should be portable, simple, and inexpensive, easy to manipulate, and of suitable intensity, but they need not be reproducible. Having been standardized in terms of secondary standards, they should remain constant over a reasonably long period before having to be recalibrated or replaced.

With this brief statement of the requirements of primary, secondary, and working standards of light, let us inquire into the present conditions regarding these three classes of standards. First, Is there a satisfactory primary standard of light? I think you will all agree with me that there is not. Many such standards have been proposed from time to time, and at present there are three or four such standards in actual use. This last fact in itself indicates that there is no one standard sufficiently superior to the others to warrant its general adoption. And if we look over the tables of relative values of these different standards and compare the values found at one laboratory with those found at another, or those obtained in recent determinations with those accepted as the best of previous determinations, it is evident that there is an uncertainty in the ratios well beyond the limit of the error of measurement.

(*To be continued.*)

A Form of Cosine Flicker Photometer.

By J. S. Dow.

(*Phil. Mag.*, November, 1907.)

In this paper the author describes a form of photometer in which the cosine law is utilized in such a way, that it is possible to keep both photometer and sources of light stationary. The photometrical surfaces consist of the two sides of a Ritchie wedge rotated about their line of intersection, and the relative brightness of the two sources compared is ascertained by the indication of a pointer attached to the moveable wedge.

This type of instrument is stated by the author to be very convenient for certain purposes, but care is necessary to avoid the possibility of "angle errors," *i.e.*, errors introduced by any uncertainty as to the exact angle at which the rays of light strike the photometrical sources. To avoid this possibility the sources of light should preferably not be brought within about a distance of 1 metre from the photometer, and wherever possible the "double-comparon" method of photometrical measurement, which eliminates any want of symmetry in the photometer, should be used.

The instrument may be used on the "equality of brightness" principle, or, by utilizing an oscillatory lens on the rood system, as a flicker photometer. The author quotes some results as showing that good agreement, from a practical point of view, between the two methods was obtained in this case, but intimates that this might not be true for all regions of the retina, or in the case of very marked colour-differences.

Finally, some experiments on the application of Crova's principle to the comparison of lights of different colours are described. According to the principle of Crova, the integral luminosity of the spectrum of an incandescent source can be expressed in terms, if the luminosity is near $\lambda = 0{\cdot}582\mu$. Crova, therefore, proposed to view the two illuminated surfaces in a photometer through a special solution absorbing all rays but those in this neighbourhood.

The author employs this plan in connexion with both the methods of "equality of brightness" and "flicker," and finds that, though somewhat difficult to apply, the method gives fairly correct results when comparing the most commonly occurring sources of light. The general conclusion, is emphasized, however, that while Crova's method may be applicable to sources of light which yield a continuous spectrum, it assuredly is not so in the case of spectra broken up into isolated groups of lines, such as that yielded by the mercury vapour lamp.

The Nomenclature of Photometrical Quantities and Units.

(From the *Jour. für Gasbeleuchtung und Wasserversorgung*, Sept. 21, 1907.)

ADOPTING the recommendations of the International Electrical Congress in Geneva in 1896, and subsequently of their own congress in 1897, the 'Deutsche Verein von Gas- und Wasserfachmännern' and the 'Elektrotechniker Verein' have decided on the following description and nomenclature of the various photometrical quantities:—

1. The unit of light is the "Candle," and is defined in terms of the horizontal intensity of the Hefner lamp.

2. The following terms and symbols are to indicate the photometrical quantities and units:—

Quantities.		Units.	
Term.	Symbol.	Term.	Symbol.
Light Intensity (Lichtstärke) ...	J	Candle (Hefnerkerze)	HK
Light-flux (Lichtström)	$\phi = J\omega = \frac{J.S.}{r^2}$	Lumen	Lm
Intensity of Illumination (Beleuchtung)	$E = \phi = \frac{J}{r^2}$	Lux or Candle-metre (Metrekerze)	Lx
Surface-brightness (Flächenhelle)	"e" $= \frac{J}{S}$	Candles per squ. cms. (Kerze auf 1 q. cm.)	—
Output of Light (Lichtabgabe) ...	$Q = \phi . T.$	Lumen-hour (Lumen-stunde) ...	—

Where ω denotes a solid angle; S, a surface in square metres; s, a surface in square centimetres, both perpendicular to the direction of the rays of light striking them; r, a distance in metres; T, a time in hours.

Dr. Hugo Krüss gave the following explanations of these terms at the annual congress at Leipsic in 1897:—

"By 'flux of light' is meant the total quantity of light radiated from a source of light within a solid angle (ω), or the total amount of light which a surface (S) receives, which is a distance (r) from the light-source.

"If one takes for this surface (S) the inner-surface of a sphere of radius (r) the flux of light becomes the total amount of light radiated by the light-source in question. The unit flux of light may therefore be defined as that quantity of light which will be radiated by a source of intensity 1 H.K., within a unit solid angle, or upon a unit surface of 1 square metre, distant 1 metre from the source of light. This unit flux we term '1 Lumen,' and designate by 'Lm.'

"The intensity of the illumination of a surface (E) is measured in lux (Lx), a quantity which has the same meaning and magnitude as the quantity hitherto known as the 'candle-metre.' This quantity is defined as the ratio of the light-flux to the area of the surface illuminated by it, in square metres, or, as the ratio of the intensity of the source of light to the square of its distance away from the surface it illuminates.

"On the other hand, by the 'surface-brightness,' 'e,' is understood, the brightness of a surface, expressed in candles per square centimetre. One understands by an 'intensity of illumination' of 1 candle-metre, that illumination to which a surface distant 1 metre from a source of 1 candle-power, will be subjected.

"But in the case of surface-brightness, we take as our unit the brightness of that surface, each square centimetre of which radiates with an intensity of 1 candle-power. The surface-brightness is, therefore, as far as the surface derives its brightness from an external source, not dependent upon the brightness of the illuminating source, and its distance

away from the illuminated surface alone, but also upon the *nature* of the surface illuminated.

"The term 'surface-brightness' is also specially applicable to bodies which themselves radiate light, such as the carbon filament of the electrical glow-lamp or the incandescent surface of the incandescent mantle, &c. In view of this application of the term we select one square centimetre as our unit surface and not one square metre."

The last term of the series, "the output of light," refers to the product of the total amount of light emitted by a source of light by the period of time during which the light is emitted.

There remains only the conception of "intensity of light" and the consideration of the recommendations of the second congress of the International Photometrical Commission in Zürich in 1907, which refer chiefly to the designation of the total flux of light from a source, as determined by the newer photometrical apparatus designed for this purpose.

The intensity of light is to be designated by the symbol "J_2," provided with an index which shall signify, under what conditions the measurement of intensity was carried out (*i.e.*, whether horizontal, spherical, or hemispherical values).

The following signs are to be utilized:

I_h, horizontal intensity.

$I_\alpha s$, intensity at an angle α to the horizontal in the upper hemisphere.

$I_\alpha i$, intensity at an angle α to the horizontal in the lower hemisphere.

Io, mean spherical candle-power.

$I_{\supset}$, mean hemispherical candle-power, lower hemisphere.

$I_{\subset}$, mean hemispherical candle-power, upper hemisphere.

$I_{max}s$, $I_{max}i$, maximum intensities at an angle α to the horizontal in the upper (s), and lower (i), hemispheres respectively.

The Tantalum Lamp with High Resistance Filament.

By L. H. Walter.

Electrician, November 22nd.

In this article the author comments on the fact that the great difficulty in the case of tantalum lamps is the low resistance of the filament, which admits of not less than 25 c.-p. on 110 volts. The recent B.T.H. Patent (B.P. 21,511 of 1906) is mentioned, according to which the resistance of the filament can be raised by a special process to about four times its original value. The filament is heated by passing a current through it for fifteen minutes at a pressure of 15 m.m. of mercury in an atmosphere of nitrogen. During this process the resistance (cold) of the filament changed from 65 to about 240 ohms. The author has tried treating tantalum lamps in the same way, and succeeded in producing a very similar alteration of resistance from 51 to 190 ohms. To the naked eye, the wire, after treatment, did not appear to have changed very perceptibly, except that the metallic lustre was less marked. On trying to take out the filament, however, it was found to be no longer strong, flexible, and springy, but so brittle, that pieces longer than one inch in length could only be obtained with difficulty.

The tensile strength was also found to be very small, compared with Dr. von Bolton's value. The general qualities of the filament, in its two states, are as exhibited below.

	Untreated.	*Treated.*
Appearance of Surface.	Metallic lustre.	Bright and dull.
	Uniform surface.	Irregular patches.
,, Fracture.	Fine, granular.	Coarsely crystallize.

The author suggests, therefore, that this method is apparently not directly applicable to the glow lamp industry, because it is just this very springiness of the tantalum lamp which enables it to compete with the highly efficient but more brittle metallic filament lamps. He also remarks that more attention might be paid to the Siemens and Halske patent (No. 9,109, 1906), according to which a metallic filament is put in series with a carbon filament in the same bulb. It is then possible to use quite a short length of metallic filament, and the efficiency may still be fairly high, especially if the metallized carbon filament is employed.

Oil-Lighting at the International Petroleum Congress, Bucharest, 1907.

At the recent International Petroleum Congress in Roumania the question of illumination received consideration, attention being chiefly directed to the necessity of devising some practical method of testing the illuminating power of oil intended for lighting purposes.

The contributions to the discussion of the question included the report of the French section, and papers by M. Aug. Pihan, Herr Curt Proessdorf, and Mr. Leon Gaster.

It was pointed out that the petroleum products intended for lighting purposes had not been hitherto uniformly tested with a view to their subsequent value in this respect.

Such oil was merely defined as the distallate passing over between 150 and 300 degrees Cent., and tests were carried out on the basis of density, inflammability, calorific value, and so forth, but little or no attention was paid to *illuminating power*—in this case the most essential quality of all. The purchaser of oil intended for domestic lighting was thus often unable to obtain any information on the very point with which he was most concerned.

It was further pointed out that different varieties of petrol require to be burnt under different conditions in order to secure the best lighting effect, and that a type of burner designed to burn Roumanian oil will not answer in the case of the American or Russian product.

Herr Proessdorf, in his communication, further lays stress on the fact that such data as have been published on this subject are very incomplete, and their value is often restricted by the fact that essential details of the variety of oil burnt, the nature of the burner and chimney, &c., are omitted. In order to illustrate the variety of burners, &c., existing, he mentions that he has recently had 150 different lamps submitted to him for examination, and gives a broad classification of the different types of burners and chimneys examined. He also discusses the designs of such burners and chimneys from the point of view of securing good illumination, and smokeless and steady flames, and points out how their design is affected by the character of the petroleum burned. Finally, he suggests a method of photometrical testing of oil lamps on similar general lines to that prescribed by the French section, but differing in several essential details.

The French section proposes to specify two standard burners, and also suitable wicks and chimneys for use with them, and the standard dimensions of them are given in detail in M. Pihan's communication.

The "Kosmos" burner is intended for use with oils of the American variety, poor in carbon, commonly used for domestic lighting. The "Luchaire" type, on the other hand, is specially designed to allow complete combustion of the richer oils.

Recommendations are also given to M. Pihan's paper as to the method of testing, including details as to the setting up of the lamps and preparation of the wick previous to test.

In the absence of the much to be desired international standard of light, M. Pihan advocates the use of the Carcel lamp.

The tests are to be carried out on three lamps simultaneously. At the expiration of one hour's burning the flame of each lamp is so regulated as to produce 1 C.P. (Carcel).

Each lamp is then weighed, and the exact time at which the weighing is carried out noted. The lamps are then allowed to burn for ten hours continuously without the initial regulation being altered in any way, either by adjusting the wick or substituting a new chimney. Measurements of the candle-power are made at intervals of 2, 6, and 10 hours after the commencement of the tests; the lamps are re-weighed at the end of the ten hours.

From these data the mean luminous intensity of the flame, and the mean consumption of oil per hour, and, finally, the consumption of oil per C.P.-hour during this period can be calculated.

The "duration of useful illumination"

is defined by the French section as the time which must elapse before the C.P. of the lamp has fallen to 20 per cent. of its mean value. It is conveniently determined graphically by observing the point at which the curve connecting the C.P. of the lamp, and the timse, cut the horizontal line, representing the mean C.P.

These foregoing regulations refer to the "Kosmos" type of burner. In the event of the "Luchaire" burner being used similar methods of test are prescribed, except that the C.P. is now regulated initially to 0·6 Carcels only, and that tests of C.P. are now made after the duration of 5, 10, and 14 hours.

Apart from the desirability of testing the illuminating power of lamps burning petroleum, the conditions governing the safe use of lamps of this description are also important, and the oil lamp has suffered in the past through want of authoritative ruling on this point.

The value of this question from an industrial point of view was urged by Mr. Leon Gaster, who, at the conclusion of a paper on 'The Petroleum Lamp,' moved a resolution, which was adopted, that the Bureau of the Congress should study and fix upon a type of domestic lamp offering the conditions of greatest safety and highest efficiency.

BIBLIOGRAPHY.

"Appareils à methode permettant de caractériser la valeur éclairante des pétroles lampants destinés à éclairage."—(*Rapport, deposé par le Groupe Francais.*)

Description des appareils et de la méthode d'essais (*par M. Auguste Pihan*).

Praktische Brennversuche und photometrische Prüfung an Leuchtpetroleum (*von Curt Proessdorf*).

Shop Lighting.

From *The Electrical World.*

IN a note referring to the recent paper of Mr. Pearson on 'Shop-Lighting,' the writer describes the method employed in the lighting of certain premises in New York as follows:—

"Those who have visited the store, during the progress of these tests, know full well that the improvement in general appearance, and the good impression on the public, is fully as marked as the improvement and efficiency shown by the illumination designs. Roughly speaking, almost any of the well-designed modern systems tried in this store gave better illumination on the counters than the old system, with one half the power used in the latter, and this, too, with an immense improvement in the general appearance of the store. Can anything more strikingly illustrate the practical importance of good illuminating design?"

Light and Cleanliness.

IN his presidential address to the Association of Engineers in Charge on November 13th on 'Economic Considerations on the Management of Plant,' Mr. Patchell emphasized one point of great interest to those responsible for the management of plant.

"Good lighting," he said, "is conducive to economy in both engine and boiler rooms, as plant in a badly lighted room never gets properly looked after or cleaned. Why should it? It is no credit to the cleaner if it cannot be seen. Dirt is about the worst disease a plant can suffer from, as it invariably means neglect of small indications and warnings, timely attention to which would prevent the otherwise inevitable breakdown. Not only is the plant better cared for, but men all work better in cheerful surroundings, and lose less time through sickness"

The Küch Mercury Lamp.

By O. Bussmann.

(Abstracted from the *Electrotechnische Zeitschrift*, 1907, vol. xxxviii.)

The essential features of this lamp consist in the facts that the pressure of the mercury vapour in the lamp is very much higher than in the older mercury lamps, that the power consumed by a lamp of given dimensions is increased, and that the consequent high temperature is favourable to greater efficiency.

The mercury vapour tubes hitherto available, which were intended for 110 volts, were nearly 1 metre in length and about 3 to 4 centimetres in diameter. The Küch quartz tube, intended for 110 volts, is only about 8 centimetres long and 1 to 1½ centimetres in diameter.

The study of the best conditions in the tubes formerly employed showed that the curve of "inefficiency" reaches a minimum near 0·6 watts per H.K. If more energy is given to the lamp the efficiency continues to fall off until the glass tube begins to soften.

Dr. Küch, however, has utilized a tube made of quartz glass, which permits of a much greater energy-consumption and higher temperature.

He finds that after reaching a maximum near 1·2 watt per H.K. the inefficiency begins to fall again, and eventually an inefficiency as low as 1·6 watt per H.K. is obtained.

The author also quotes some recent tests of the Reichsanstalt, according to which 3,000 H.K. (mean spherical), and an inefficiency of 0·27 watt per mean spherical C.P. was obtained.

Under these conditions the colour of the light yielded by the lamp is also much improved, the ordinary discontinuous spectrum of mercury being partially replaced by a continuous one, and a distinct red element thereby introduced.

Yet the colour of the light seems to be still such as to render the lamp chiefly useful for the illumination of outdoor spaces, parks, and gardens, station-platforms, and the like.

There is one feature of the lamp which must certainly be regarded as a partial drawback to its use for ordinary purposes of illumination, namely, the transparency of quartz-glass to ultra-violet light. In the older mercury lamps the glass tube almost completely absorbed these ultra-violet rays, but the quartz tube lamp is so powerful in energy of this description that an exposure of only a few seconds causes an inflammation of the skin lasting for several days, while the subsequent "browning" of the skin is visible months afterwards.

The dangerous action of ultra-violet light on the eyes is well known, and to avoid injury of this kind the lamp is surrounded by a suitable dense glass globe. This precaution might prove hardly adequate when one remembers that the globes surrounding arc lights in the streets are occasionally broken. Stringent precautions are also necessary to provide against the possibility of a careless or ignorant user of the lamp removing the protecting globe. This very richness in ultra-violet light, however, is said to render the lamp valuable for special purposes, such as the treatment of skin diseases and the sterilization of drinking water, photography, &c.

In the discussion of Dr. Bussmann's paper some difference of opinion was expressed as to how far exact photometry of the mercury lamp is possible. Hahn insisted that the spectrum of the mercury lamp differed so greatly from the other common sources as to render its photometrical comparison with them out of the question. L. Bloch, O. Bussmann, and others, however, had found no serious practical difficulty.

Two possible methods of improving the spectrum of the light were also suggested. Dr. Gehrcke mentioned the value of adding certain metals, the spectrum of which contains lines in the red, to the mercury used in the lamp. Wangemann suggested the possibility of utilizing the high temperature of the mercury lamp to render some refractory material incandescent, thus obtaining a continuous spectrum.

Heraeus stated that these methods had been tried. The amalgam method failed, because the added metal tended to gradually separate out at one pole. He had also investigated the second method, utilizing Nernst materials and metallic oxides, but without satisfactory practical results. All impurities—and metallic oxides must here be so considered—affect the durability of the lamp.

REVIEWS OF BOOKS.

A HANDBOOK OF PRACTICAL GASFITTING.

By Walter Grafton.

Published by B. T. Batsford, London, 7s. 6d. net.

Although, as the title of Mr. Grafton's book implies, its contents are mainly devoted to the subject of gas-fittings, yet there are certain portions of this work which contain information of practical value to those connected with illumination. Besides dealing broadly with the practice of running mains, meter fixing, &c., the author refers to special departments of gas-lighting, such as street-lighting, switch-gas-lighting, the illumination of workshops, &c. We are fully in agreement with Mr. Grafton when, in this connexion, he recommends the consumer to insist upon a high standard of work, as being invariably cheapest in the long run.

The appendix of the book also contains a quantity of interesting and useful information. The work, as a whole, appears to be of a thoroughly practical manner, and being, in addition, excellently written and well illustrated, deserves the attention of all those connected with gas-lighting.

TOWN GAS AND ITS USES.

By W. H. Y. Webber.

Published by A. Constable & Co., Ltd., London, 6s.

In this book the reader will find much interesting information on the subject of gas-lighting. The first three chapters are devoted to a description of the nature, manufacture, and historical development of ordinary "town" gas. Mr. Webber then proceeds to deal with the theory and mechanism of both flat-flame and incandescent gas lights, mentioning the recent developments of the inverted burner, and also briefly touching on the merits of high-pressure gas-lighting.

The scientific side of illumination is also insisted upon by the author, under the heading of 'Practical Gas-Lighting.' After stating what he considers to be the essential qualities of successful gas-lighting, he touches on certain important practical cases of illumination, such as shop-lighting, railway-yard lighting, church-lighting, and so forth, and winds up by giving a few sound and simple rules, which are, nevertheless, unfortunately, not infrequently ignored by those responsible for the lighting installations of the present day. Not the least interesting section of this work is that devoted to the legal aspect of gas supply, and a feature of Mr. Webber's book, which deserves special recommendation, is the simple and attractive way in which the subject is presented; this will, doubtless, render it of special value to many who are not personally connected with the technicalities of gas-lighting.

GRUNDZÜGE DER BELEUCHTUNGSTECHNIK.

By Dr. L. Bloch.

Published by Julius Springer, Berlin.

This little book is devoted to an exposition of the fundamental principles underlying illumination, and their practical application. The chief photometrical definitions and units are simply and clearly explained, and the writer uses the now generally accepted notation to designate the various quantities dealt with.

The author next turns to the theoretical aspect of light measurement. He explains the nature of mean spherical and hemispherical candle-power, and describes graphically methods by means of which they can be calculated from the polar curves of light-distribution of sources. All this is illustrated by figures and diagrams of actual results with different sources of light, and various types of enclosing globes, &c.

Attention is also paid to the application of these data to the practical lighting of streets and buildings, illustrated by records of practical experience, such as the illumination of Friedrichstrasse, Berlin, which render the treatment of this subject especially valuable.

A special chapter is given up to indirect lighting; the influence of the diffusion of light from ceilings, wall-papers, and so forth, is mentioned, and some tables of recent determinations of the coefficients of reflection from various materials are included.

Dr. Bloch has dealt with his subject with great care and thoroughness, and we have no doubt that the book will form a valuable addition to the technical literature bearing on the scientific aspects of illumination.

Review of the Technical Press.

General Illumination.

The growing interest in illumination in this country has recently found expression in the columns of our technical journals.

Mr. Gaster's paper on 'The Province of the Illuminating Engineer,' before the Society of Engineers in Charge, has also given rise to the discussion of this subject.

Attention has been drawn to the very vital distinction between the mere production of light—however efficiently—and the successful utilization of the light which we have produced. The subject of illumination is rendered specially difficult by the fact that the physical side of the question—the problem of choosing our light-giving substances, and marshalling the atoms at our disposal so as to secure efficient light-production—is complicated by the physiological peculiarities of the eye. Our eyes behave very differently in their perception of strong and weak illumination. Possibly the light which is good for reading purposes may not be the best for other purposes, &c. And, as one of the writers on this subject remarks:

"This point of view is far away from that of the average man with a photometer, who makes simple tests of 16 c.-p. lamps. It shows that it will be probably years before the amount of knowledge concerning illuminating engineering will be sufficient to render operations in this field at all commensurate with the development in other spheres of engineering activity."

On the other hand, some fear has been expressed lest the scientific side of illumination may be so strongly put forward that the ordinary man may be scared into the belief that illuminating engineering is too complex for him to understand. It has likewise been maintained that the rules of good lighting are few and simple, and that there is no need for the existence of a new expert in illuminating matters to deal with them.

These different views are especially interesting at the present time, when the formation of an illuminating engineering society is being proposed in this country. It is certain that the study of lighting and illumination cannot be at once as simple and as complicated as these differing opinions would suggest.

It will, however, be readily admitted that the most immediate and urgent needs of illumination can be met by considerations of a simple, commonsense character, and that much good work can and will be done by those who, for instance, have little knowledge of physiological optics or the theory of the radiation from incandescent materials. For the moment these urgent needs must be kept in view. Yet the scientific considerations cannot be shelved indefinitely if illumination is ever to become an exact science.

And the very existence of this difficult scientific background only proves the need for a body of men willing to give their attention to its complexities.

In *The Gas World* Mr. S. F. Walker deals chiefly with the limitations of the "candle-foot" as a standard of intensity of illumination (*Gas World*, Dec. 7). He rightly draws attention to the necessity for taking into account the angle at which the rays strike the illuminated surface and the amount of light reflected by the illuminated surface. Many, however, will agree with the editorial comments on Mr. Walker's article in deprecating the proposal of a new system of nomenclature involving such terms as 10,000 "rays" per square inch, &c., when we have already a carefully defined and selected set of photometrical quantities decided on at the international photometrical conventions.

Mr. Haydn Harrison (*Elec. Review*, Dec. 6) gives the results of a series of tests carried out in Cannon Street, Holborn Viaduct, Queen Victoria Street, and Farringdon Street. Cannon Street proved to be the best lighted street of

the four, and Farringdon Street the worst. Some curves are also given illustrating the extremely low value of the minimum illumination which was found to occur, and the important conclusion is arrived at that the superiority of the lighting in Cannon Street is due to the better spacing of the sources of light, and not to additional expense.

Photometry.

A recent report to the American Gas Institute, on 'Methods of Testing the C.-P. of Gas,' contains many points of general interest from the point of view of photometry, and especially as regards the use of flame-standards of light. The dimensions of the photometer room are fully discussed, and the necessity of careful provision to avoid the possibility of draughts in accurate testing is also insisted upon, even to the point of recommending the introduction of previously warmed air from an adjacent room.

The well-known and marked influence of bad ventilation, barometric pressure, and humidity on the C.-P. of flame standards of light are also referred to.

Finally, the existing standards of light are reviewed, and the need for a generally accepted international standard emphasized.

A most interesting and valuable report. Wild (*Electrician*, Nov. 8, 1907) deals with the sensitiveness of various photometers, which include the Lummer-Brodhun, the grease-spot, the Simmance-Abady, and his own type of grease-spot flicker photometer. He finds that two of the types of photometers examined exceed the flicker-types in sensitiveness when the two lamps compared yield light of exactly the same colour.

On the other hand, the flicker-photometer gave the best results when the two sources compared differed in colour and their superiority became more pronounced as the colour-difference became more marked.

Such experiments are useful, yet one cannot help feeling that the value is in this case restricted by the fact that the results quoted depend upon the author's experience alone. It is certain that many observers would conscientiously obtain quite different results from some of those here given, and only a series of experiments by a large number of observers, carried out under exactly the same conditions, can really definitely decide which is the best of the modern types of photometers. Now that a number of new photometers are finding their way into use, the desirability of an authoritative and impartial series of tests of this description is evident.

Dow (*Electrical World*, Nov. 30, 1907) contributes an article on 'The Problem of Colour-Photometry.' The author remarks that until recently our sources of light were very similar in colour, but the use of "selective radiation" enables us to obtain light of very varying colour, and we may eventually hope to gain greater control over the spectrum of illuminants. The point is insisted that it is naturally impossible to obtain all the desired information about the capabilities of a source of light by any mere photometrical test, especially in the case of light of different colours. Therefore the suggested method of comparing lights which differ in colour by a method involving visual acuity, is not, strictly, a photometric one, and cannot be applied to general questions of illumination. It is also pointed out that such methods are complicated by the fact that the eye is not achromatic, and that whereas the red portion of the spectrum is the best for distant vision, the contrary is the case if the detail is to be viewed at very close quarters.

The physiological complexity of the eye and its influence on colour-photometry is also dealt with, the Purkinje effect and the "Yellow-spot" effect being mentioned in connexion with the recent theory of the action of the "rods" and "cones" in the eye. Finally the author gives a brief *résumé* of the various methods which have been proposed to facilitate colour-photometry, the natural conclusion being reached that the difficulties of the subject are only postponed, and not avoided by such methods.

Krüss (*Jour. für Gas*, &c., Nov. 2) describes a form of apparatus specially intended for the study of the distribution of light from inverted mantles.

In the *Journal of Gas Lighting* (Dec. 10) another recent article by Dr. Hugo Krüss comparing the merits of the upright and inverted types of mantle lighting is reproduced. The author gives a number of curves illustrating the distribution of light in the two cases, both with clear and opal globes, and emphasizes the point that mere measurement of the M.S.C.P. of the two sources does not constitute a comparison of their merits for general purposes of illumination. His results also proved unfavourable to the inverted mantle, but Drehschmidt, in a recent letter to the *Journal für Gas*, &c., states that Krüss's results do not apply to the most modern form of inverted incandescent mantle, which he considers

to be undoubtedly more efficient than the upright form.

Electric Lighting.

Prof. Teichmuller, in a recent article (*E.T.Z.*, Oct. 17, 1907), compares the standard specifications for glow-lamps enforced in Germany, Austria, Switzerland, and England respectively. The conditions enforced in Switzerland and Austria naturally resemble those contained in the earlier German specification. The English specification — the most recently issued—deviates somewhat further, but this, too, is founded on the same general considerations.

The latitude of variation in watts per C.P., allowed in the different specifications differs somewhat, Austria allowing only 4 per cent., while in England a latitude of 8 per cent. is allowed in the case of individual lamps, and an average of 5 per cent.

Fortunately, all countries are in agreement as to the definition of "useful life," namely, the time elapsing before the C.P. of the lamps in use has fallen 20 per cent. At present, life tests are to be carried out at the P.D. on which the lamp is intended to run. The German, Swiss, and English specifications do not definitely propose "overrunning life-tests," though the two former nations refer to this method.

Austria-Hungary proposes to test lamps by running them for twenty-four hours at 20 per cent. above normal pressure. Recent experiments are said to confirm the value of this test. Manufacturers, however, point out that the method would have to be applied with caution to the comparison of different makes of lamps, owing to the different qualities of the carbon used.

It may be noted that, in the case of England and Switzerland the conditions imposed by the specification are always applicable, while in Germany and Austria they only apply when the number of lamps ordered exceeds a certain value.

There is a general impression that the specifications are too severe to be rigidly enforced. Yet their educational value to the consumer is not to be despised.

The Electrical Engineer (Dec. 6) contains an article by "A lamp maker," discussing the influence of the new metallic filaments on central station revenue. He takes a rather sombre view of the situation, contending that neither the presumable increase in the number of consumers nor their supposed increased consumption of light can make up for the direct loss of revenue arising from the greater efficiency of the new lamps. The only solution he sees lies in the adoption of some radically different method of connecting and charging.

Recent issues of the *Zeitschrift für Beleuchtungswesen* contain notes on further processes connected with the manufacture of glow-lamps; for instance, a new method of exhausting the bulb by means of a small tube let into the base of the lamp. The exhaustion of the bulb and sealing in of the filament are thus carried out in one operation, and the production of the "pip"—a fruitful source of breakage—is avoided.

The scientific principles underlying the new metallic glow-lamps have been the subject of a recent paper by Stark (*E.T.Z.*, Oct. 24, 1907), who contends that these lamps owe their high efficiency to their high temperature of incandescence.

The same conclusion is reached in an article on the tungsten lamps in the *Revue Electrique* (Nov. 15, 1907).

Walters (*Electrician*, Nov. 22, 1907) describes a B.T.H. method of increasing the resistance of tantalum filaments.

Gas Lighting.

Attention may be drawn to two recent papers on gas lighting, by H. Kendrick and H. Burgess.

The former deals chiefly with the maintenance and adjustment of incandescent burners. The latter describes the high-pressure system of lighting on the Midland Railway.

Two interesting special appliances for the study of incandescent mantles have recently been devised. The first of these is intended to test the vibration and "shock-resisting" power of mantles, and is so arranged that, as a handle is turned, the mantle is alternately lighted and extinguished, and simultaneously receives a series of shocks.

The second is an optical device by means of which the change in shape of a mantle during its life can be accurately studied.

A rightly designed burner provides a flame of such a shape that the mantle utilized with it is completely encircled by the hot outer region of the flame. Therefore, as the mantle changes its shape, portions of it are withdrawn from this hottest region of the flame, and do not glow as brightly as they should do.

In increasing the life of incandescent mantles, our object should therefore be to devise a mantle which retains not only its exact original chemical proportions, but also its original correct shape.

The Journal of Gas Lighting for Dec. 3 contains an abstract of a recent paper by Winkler (*Jour. für Gas*, &c., Oct. 5, 1907) on the application of inverted burners to street lighting. Among other questions the author discusses the distribution of light from the inverted mantle, and the shape which ought to be given to the reflectors placed above them so as to secure the best distribution of light. Other interesting papers, which space does not allow us to deal with, are included in the following table :—

ILLUMINATION.

Editorial Notes. *Electrical Review* (Oct. 4, Oct. 25, Nov. 8).
Gaster, L. The Province of the Illuminating Engineer (The Society of Engineers in Charge, Dec. 11).
Harrison, H. T. The City Lighting (*Electrical Review*, Dec. 6).
"Multipolaris," Freaks and Fallacies in Illumination (*Am. Illuminating Engineer*, Nov.).
Walker, S. F. The Science of Illumination (*Gas World*, Dec. 7).

PHOTOMETRY.

Dow, J. S. The Problem of Colour-Photometry (*Elec. World*, Nov. 30).
Krüss, H. Photometrierstative für hängendes Gasglühlicht (*Jour. für Gas*, &c., Nov. 2).
Krüss, H. A Comparison between Inverted and Upright Incandescent Gas Lights (*J. G. L.*, Dec. 10).
Wild, L. The Sensitiveness of Photometers (*Electrician*, Nov. 8).

ELECTRIC LIGHTING.

'A Lamp Maker." Metallic Filament Lamps—How will they affect Electricity Undertakings? (*Elec. Engineer*, Dec. 6).
Guye and Zebrikoff. Experiments on the Electric Arc (*E. T. Z.*, Dec. 5, p. 1177).
Niethammer. Metalfadenlampen (*Elektrot. u. Masch.*, Nov. 24).
Patents. Bogenlichtkohle zur Erzeugung hochactinischen Lichtes, Dr. Marquart, D.R.P. 176419 (*Zeit. für Beleuchtungswesen*, Nov. 20).
Filaments for Gas and Electric Lighting (*J. G. L.*, Nov. 5).
Verfahren zur Betriebe von Quecksilberdampflampen (*Zeit. für Bel.*, Nov. 30).
Verfahren zur Herstellung elektrischen Glühlampen (*Zeit. für Bel.*, Nov. 10).
Stark. Prinzipien der neuen Verbesserungen der Ökonomie elektrischen Lichtquellen (*E. T. Z.* Oct. 17).
Teichmuller, J. Technische Bedingungen für die Lieferung von Glühlampen (*E. T. Z.*, Oct. 17).
Upson, W. L. Observations on the Electric Arc (Paper read before the Physical Society, *Electrician*, Oct. 25 and Nov. 1).
Voss and Zinck. Mitteilungen über elektrischen Metallfadenglühlampen und hängendes Gasglühlicht (*Jour. für Gas*, &c.).
Walters, H. L. The Tantalum Lamp with High Resistance Filament (*Electrician*, Nov. 22).
Lampes au Tungsten (*Rev. Electrique*, Nov. 15).
The Crompton-Blondel Arc Lamp (*Electrician and Electrical Review*, Nov. 29).

GAS, OIL, AND ACETYLENE LIGHTING.

Brearley, J. H. Gas Hygiene and Ventilation (*Gas World*, Nov. 21).
Burgess. High-pressure Lighting on the Midland Railway (*Jour. of Gaslighting*, Oct. 15).
Fischer. Zur Theorie des Auerlichtes (*Zeit. für Bel.*, Nov. 30).
Goodenough, F. W., and Wallis Jones, R. J. The Advantages of Gas and Electric Lighting (*Jour. of Gaslighting*, Oct. 29).
Kendrick, H. The Maintenance and Adjustment of Incandescent Burners (*Jour. of Gaslighting*, Nov. 5).
Webber, W. H. Y. The Puzzle of Petrol Air Gas (*Gas World*, Nov. 2).
Winkler. Inverted Burners for Street Lighting (from the *Jour. für Gas*, &c., see *Jour. of Gaslighting*, Dec. 3).
Eine einfache Vorrichtung um Deformationen von Glühkörpern zu bestimmen (*Jour. für Gas*, &c., Nov. 2).
A New Mantle-testing Machine (*Jour. of Gaslighting*, Oct. 22).

PATENT LIST.

PATENTS APPLIED FOR, 1907.

I.—ELECTRIC LIGHTING.

24,635. Arc lamps. Nov. 7. W. A. Legge, 65, Chancery Lane, London.
24,706. Arc lamps (C.S.). Nov. 7. Johnson & Phillips, Ltd., and C. F. Tubbs, Birkbeck Bank Chambers, Southampton Buildings, London.
24,813. Filament for glow lamps. Nov. 9. J. W. Ward and R. H. Stevens, 140, High Rd., Ilford, Essex.
25,117. Arc lamps. Nov. 12. The British Thomson-Houston Co., Ltd., and W. H. Dalton, 83, Cannon Street, London.
25,304. Incandescent test or like lamps. Nov. 14. H. Brough, 18, Southampton Buildings, London.
25,355. Arc lamps. Nov. 15. P. M. Capitaine, 43, Boulevarde Voltaire, Paris.
25,881. Arc lamps. Nov. 22. D. Suchostawer, 33, Chancery Lane, London.
26,135. Enclosed arc lamps. Nov. 26. G. W. Farthing and T. K. Steanes, 77, Chancery Lane, London.
26,179. Manufacture of hollow metal filaments for incandescent lamps. Nov. 26. F. W. le Tall, 2, Norfolk Street, Strand, London. From A. Lederer, Austria.
26,294. Means of supporting filaments in incandescent lamps. Nov. 28. F. Harrison, 16, Ossian Road, Stroud Green, London.
26,838. Lamp filaments from metals and metallic oxides of high fusing point (C.S.). Dec. 4. H. P. R. L. Pörscke, 31, Bedford Street, Strand, London.
26,839. Lamp filaments from metals and metallic oxides of high fusing point (C.S.). Dec. 4. H. P. R. L. Pörscke, 31, Bedford Street, Strand, London.
26,840. Manufacture of lamp filaments, and securing same to leads (C.S.). Dec. 4. H. P. R. L. Pörscke, 31, Bedford Street, Strand, London.
26,841. Manufacturing filaments of non-fusible metals (C.S.). Dec. 4. H. P. R. L. Pörscke, 31, Bedford Street, Strand, London.
26,846. Arc lamps (C.S.). Dec. 4 (I.C. Dec. 5, 1906, Germany). Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
27,034. Arc lamps. Dec. 6. W. J. Davy, 40, Chancery Lane, London.

II.—GAS LIGHTING.

25,240. Inverted incandescent burners. Nov. 14. Sunlight and Safety Co., Ltd., and T. B. Smith, 5, Corporation Street, Birmingham.
25,657. Manufacture of incandescent mantles. Nov. 19. J. T. Robin, 7, Southampton Buildings, London. From S. Salomon, Germany.
25,846. Electrical gas lighting and extinguishing device. Nov. 22. J. M. Stewart and A. G. Rendall, 100, Wellington Street, Glasgow.
26,046. Inverted incandescent burner. Nov. 25. H. J. Ball, 1, Whymark Avenue, Wood Green, Middlesex.
26,286. Inverted gas lamps and burners. Nov. 28. G. Helps, Izons Croft, Anerley, Atherstone.
26,373. Upright incandescent mantles. Nov. 29. F. H. Mitchell, J. Lomax, and A. Millward, trading as Lomax & Co., 41, Corporation Street, Manchester.

III.—MISCELLANEOUS
(including lighting by unspecified means, and inventions of general applicability).

24,871. Burners for lamps (C.S.). Nov. 9. M. F. P. Vialard-Goudon, 111, Hatton Garden, London.
25,277. Lamps (C.S.). Nov. 14. F. W. Kearsey, 111, Hatton Garden, London.
25,600. Acetylene storm-proof hand lamps. Nov. 19. T. P. Gandell, 46, Bedford Row, London. From J. Margrett., Germany.
25,695. Illuminated advertising devices (C.S.). Nov. 20. Radium-Licht-Reklame Co. m. b. H. and F. Stern, 6, Bank Street, Manchester.
25,715. Illuminated signs, facias, or the like. Nov. 20. R. F. Venner, 20, High Holborn, London.
25,874. Burners. Nov. 22. P. O. Rowlands, 8, Quality Court, Chancery Lane, London.
25,884. Vapour burning apparatus. Nov. 22. J. H. Miess, Birkbeck Bank Chambers, Southampton Buildings, London.
26,504. Illuminating bodies (C.S.). Nov. 30 (I.C. Dec. 1, 1906, Germany). O. Mannesmann, trading as Sparlicht-Ges. m. b. H., 53, Graben-trasse, Essen-on-the-Ruhr, Germany.
26,752. Devices for illuminating and examining the orifices or organs of the human body (C.S.). Dec. 3. F. E. Griswold, 6, Lord Street, Liverpool.
27,022. Oil lamps (C.S.). Dec. 6. E. R. Schreiber, 111, Hatton Garden, London.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

23,286. Arc lamps. Oct. 20, 1906. Accepted Dec. 4, 1907. A. D. Jones, 39, Hartham Rd., Holloway.
23,334. Conductors for use as incandescing bodies for lamps (C.S.). I.C. May 9, 1906, U.S.A. Accepted Nov. 27, 1907. W. D. Coolidge, 83, Cannon Street, London.
23,335. Conductors for use as incandescing bodies for lamps (C.S.). I.C. May 9, 1906, U.S.A. Accepted Nov. 27, 1907. W. C. Arsem, 83, Cannon Street, London.
23,336. Conductors for use as incandescing bodies for lamps (C.S.). I.C. May 9, 1906, U.S.A. Accepted Nov. 27, 1907. W. D. Coolidge, 83, Cannon Street, London.
26,620. Arc lamps. Nov. 23, 1906. Accepted Nov. 27, 1907. H. W. Headland and F. Plutte, 77, Chancery Lane, London.

27,569. Arc lamps. Dec. 4, 1906. Accepted Dec. 4, 1907. O. Gross, 5, John Dalton St., Manchester.
27,726. Arc lamps with mutually inclined carbon-holders. Dec. 5, 1906. Accepted Nov. 27, 1907. J. Brockie, Birkbeck Bank Chambers, Southampton Buildings, London.
28,680. Manufacture of incandescence lamps. Dec. 15, 1906. Accepted Dec. 4, 1907. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
29,423. Electric lighting of trains. Dec. 24, 1906. Accepted Nov. 13, 1907. W. R. Preston, C. Roe, and C. H. Roe, 77, Chancery Lane, London.
4,931. Arc lamps. Feb. 28, 1907. Accepted Nov. 13. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
5,576. Apparatus for treating conductors, especially applicable in manufacture of lamp filaments. March 7, 1907. Accepted Nov. 20. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
8,761. Arrangement of filament of high-voltage lamp of small energy consumption (C.S.). April 15, 1907. Accepted Dec. 4. C. Glogan, 27, Chancery Lane, London.
16,301. Electric lighting of lighthouses, beacons, or buoys (C.S.). July 16, 1907. Accepted Nov. 27. C. A. Stevenson, 28, Douglas Crescent, Edinburgh.
18,922. Production of Tungsten dioxide (C.S.). Nov. 27. Germany, I.C. Nov. 23, 1906. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Buildings, Norfolk Street, Strand, London.
18,923. Incandescent lamps (C.S.). I.C. Nov. 23, 1906, Germany. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Building, Norfolk Street, Strand, London.
19,808. Incandescent lamps (C.S.). Sept. 4, 1907. Accepted Nov. 13. W. E. Barnas and G. Weddell, 24, Southampton Buildings, London.
23,098. Manufacture of incandescent lamps (C.S.). I.C. Nov. 5, 1906, Germany. Schott & Gen, Jena, Germany.
23,351. Electric search-lights (C.S.). I.C. Nov. 6, 1906, Germany. Accepted Nov. 20, 1907. Gebrüder Siemens & Co., Birkbeck Bank Chambers, Southampton Buildings, London.

II.—GAS, OIL, ACETYLENE, AND INCANDESCENT LIGHTING.

23,116. Petroleum incandescent burners (C.S.). I.C. Oct. 20, 1905, Sweden. Accepted Nov. 27, 1907. E. H. M. Paerén, 7, Southampton Buildings, London.
29,123. Electrical apparatus for lighting gas. Dec. 21, 1906. Accepted Nov. 20, 1907. H. Nehmer, 36, Clifton Street, Finsbury Square, London.
29,155. Manufacture of incandescent mantles. Dec. 21, 1906. Accepted Dec. 4, 1907. J. Norden, 1, Great James Street, Bedford Row, London. (From C. Bartel, Germany.)
651. Testing incandescent mantles. Jan. 10, 1907. Accepted Nov. 27. H. W. Woodall and P. G. G. Moon, the Gas Works, Bournemouth.
1,349. Incandescent burners. Jan. 18, 1907. Accepted Dec. 4. T. Terrell, New Court, Temple, London.
6,179. Pilot lighting device for incandescent gas lamps. March 14, 1907. Accepted Nov. 27. R. Macfarlane, 41, Reform Street, Dundee.
8,744. Inverted incandescent burners (C.S.). April 15, 1907. Accepted Dec. 4. M. Graetz, 1, Queen Victoria Street, London.
8,972. Bunsen tubes of inverted incandescent burners. April 18, 1907. Accepted Nov. 13. A. Bray, Sunbridge Chambers, Bradford, Yorks.
15,544. Incandescent burner (C.S.). I.C. Nov. 14, 1906, France. Accepted Nov. 13, 1907. R. M. Vieu, 65, Chancery Lane, London.
19,555. Incandescent burners (C.S.). Aug. 31, 1907. Accepted Nov. 13. H. Cole, 77, Colmore Row, Birmingham.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

27,187. Acetylene lamp (C.S.). Nov. 29, 1906. Accepted Dec. 4, 1907. H. V. Neukirch and E. M. Freytag, 65, Chancery Lane, London.
28,696. Oil lamp burners. Dec. 19, 1906. Accepted Nov. 13, 1907. W. H. I. Welch, Birkbeck Bank Chambers, Southampton Buildings, London.
5,777. Hanging oil lamps. March 11, 1907. Accepted Nov. 13. J. W. B. Wright and J. H. Woodroffe, 24, Temple Row, Birmingham.
6,879. Water-drip acetylene lamps. March 22, 1907. Accepted Dec. 4. M. W. Skelton and J. Todd, 20, Dumbarton Street, Liverpool.

EXPLANATORY NOTES.

The following apply to both lists :—

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application ; date applied for under Rule 5 of the Patents Rules, 1905. In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

The following apply only to the list of Complete Specifications accepted, &c. :—

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d.*, fifteen days after the date of advertisement of acceptance.

Specifications filed under the International Convention may be inspected at the Patent Office, at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s.*

N.B.—Some of the titles are abbreviated. This list is not exhaustive, but contains a list of Patents which appear to be most closely connected with illumination.

2

DEVOTED TO THE SCIENCE AND ART OF ILLUMINATION

THE ILLUMINATING ENGINEER

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EDITORIAL.

IN this number we deal elsewhere with the subject of the "Illuminating Engineer" and the various comments which the suggestion of the new society and the creation of the new expert have called forth. The views expressed by different critics naturally differ considerably, and in some cases views even of the same critics appear to have passed through a gradual evolution since the date when the subject was first brought to their notice.

In some cases the opinion has been expressed that such a society would be useful, but that the obstacles in the way of its creation would be difficult to surmount. These critics may rest assured that the suggestion is not brought forward without these difficulties having previously been given very careful consideration, and that the necessary support demanded by the starting of such a society will be forthcoming.

In other cases the value of such a society has not been appreciated, though we think that many such objections will be found to be based upon a misconception as to what our suggestion really entails.

We are willing and anxious that all such objections should be raised, as we are sure they can be met. At the same time, we do feel constrained to point out that if those of us who are interested in the subject wish to meet together to discuss problems of illumination, we have a perfect right to do so, if we so desire, and that this should be recognized even by those who doubt the value of our labours. We merely wish to discuss these problems under more favourable conditions than exist elsewhere, and our proposals, whatever their merits, are, at any rate, certainly not of an injurious nature.

It is not as though any demand were being made upon the funds of the general public. If the Illuminating Engineers' Society were to be a public institution supported by the ratepayers, the latter, of course, would be entitled to express their approval or otherwise of the project. But in the case of the Illuminating Engineering Society nothing of this kind is proposed, and, therefore, while we invite opinions upon this subject, we do not recognize the right of those holding them to dictate to us whether or

no the society should be formed, so long as the number of members desirous of joining us justifies its formation.

The Efficiency of Light Production.

Several of the articles in the present number illustrate the abstruse nature of the scientific background of the subject of illumination. The problem of efficient light production must be viewed from two distinct aspects, and it is this dual aspect that renders the question so complicated.

Firstly, we have the physical side of the problem—the problem, that is, of selecting suitable light-giving substances which do their work efficiently, and of investigating what it really is that goes on within the atom of the illuminating substance.

Secondly, we have to remember that our impressions of light are all received through the eye, and are therefore complicated by the peculiar behaviour of that organ.

It is only of recent years that the physics of light production have been exhaustively studied, and there is yet much to be learned. It has, of course, been realized that in the case of most of our illuminants by far the greater portion of the energy expended is wasted in the form of radiation of a non-luminous character, and the recent determinations, amongst others, of Dr. Lux and Dr. Drysdale show how small is the percentage of energy usefully employed. We may eventually succeed in limiting the radiation of such a substance to within the limits of $0{\cdot}4\mu$ and $0{\cdot}8\mu$, the approximate range of visible wave length, and the figures for the mechanical equivalent of light quoted by these two authorities give us an idea what the ultimate efficiency of such an illuminant, under these conditions, might be.

Such researches as have at present been carried out on this subject lead us to suppose that we may eventually find it possible to produce a generally useful source of light which only consumes about one-tenth to one-fifth of a watt per candle-power. This, of course, refers to white light. But it may be that for special purposes we do not care about the colour of the light, but are only anxious to get as *bright* a source as possible. In such a case we have to consider which of the rays within the visible portion of the spectrum are the most effective, and we then find that, while those at the extreme ends of this range are the least serviceable, the question as to which ray is absolutely the most efficient brings in at once the physiological peculiarities of the eye.

Dr. Lux points out that the value of the mechanical equivalent of light is very different in the case of different sources, and this may be partially ascribed to their difference in spectral composition.

The Eye and Colour Perception.

The influence of the complex physiological peculiarities of the eye on problems of illumination is also very strikingly illustrated by the paper on the subject of colour photometry by Mr. Dow, which we reproduce in this issue. Heterochromatic photometry was for long regarded as of merely academic interest, but it must be admitted that, at the present day when the methods of producing light are so varied, and the difference in the colour of illuminants is so much more marked than was formerly the case, the subject has a more practical bearing. It will be remembered how, during the discussion of Dr. Bussman's paper on the mercury high pressure arc lamp, much discussion centred around the question of whether the photometry of such lamps was possible by the ordinary methods. We are constantly hearing conflicting opinions expressed on such points, and it is certainly time that these aspects of photometry were thrashed out.

What, however, we regard as of special interest in this connexion is the suggestion that we shall ultimately be able to secure light of any particular colour at will by the use of selective radiation, and that special uses may ultimately exist for light of such special character. For instance, it may be that certain rays are most effective in penetrating the atmosphere, and we therefore draw the conclusion that we ought to try to produce these rays by preference in cases in which the fog-penetrating power of light is of paramount importance.

We cannot, however, enter upon the question of colour without being forced to consider the behaviour of the eye towards light of certain wave lengths. The portion of the spectrum which is most serviceable at high illuminations may not be that portion which is most useful at very low illuminations, and, according to the most recent physiological theories, this can be explained by the consideration of the peculiar behaviour of the small organs of light perception which are distributed over the retina.

In the same way it does not follow that the portion of the spectrum which is most effective in producing the sensation of brightness is also most effective for certain other purposes; and therefore, when undertaking photometrical tests of sources yielding a peculiar coloured light, we ought to bear in mind exactly what functions the light will be called upon to fulfil in practice.

The Nomenclature of Photometrical Quantities.

We have received from Dr. Monasch a copy of his recent article dealing with the present anomalies existing in our methods of defining the unit of intensity of illumination in different countries. This article, which is abstracted elsewhere in this issue, in connexion with the list of standard photometrical definitions which we quoted in our last number, is of great interest at the present moment, and we think that many will agree with the international aspect of these questions on which Dr. Monasch rightly lays stress, and the necessity of coming to some definite understanding.

It is certainly inconvenient for workers of different nationalities to be compelled to convert results into one or other of half a dozen different existing units, and this multiplication of terms must inevitably lead to confusion. As Dr. Monasch explains, we in this country have helped to swell the number of existing terms by the common use of both the candle-foot and the candle-metre, while two values of the plural of the former, namely "candle-feet" and "foot-candles" exist.

The articles mentioned above should be of special interest to some of those in this country who appear to regard the adoption of such terms as "Lux" and "Lumen" as unnecessary efforts to complicate the subject of illumination, and, moreover, appear also to imagine that these terms were created by the American Illuminating Engineering Society. Actually, the terms in question have been in common use on the Continent for many years, and the general recognition of a carefully defined international system of photometrical units would really be of great assistance to workers in illumination. It is of the greatest importance in questions of illumination to form clear ideas of exactly what is meant by certain phrases, and to agree on certain terms and notation which will be understood and accepted all the world over, putting aside any feeling of national bias in these matters. There can be no question that in time this lack of co-operation and misunderstanding will be avoided by the general adoption of some such international system.

The "Popular" and the Scientific aspects of Illumination.

In this editorial we have made special comment upon some of the more abstruse scientific aspects of problems of light-production, and we therefore take this opportunity to refer to a feeling which we have recently seen expressed, that too much insistance upon what may be termed the purely "scientific aspect" of problems of illumination and light-production is liable to produce the impression that illuminating engineering is too complicated a subject to appeal to those at present responsible for illumination.

We have certainly no wish to produce such an impression. On the contrary, we are most anxious that contractors and others should realize the very practical bearing of the scientific side of illumination on the work with which they are associated. At present it must be admitted that the great care which is bestowed on the actual workmanship of the wiring and plumbing is not sufficiently extended to the distribution and use of the light itself.

It must be recognized that in illuminating engineering, as in other professions, there will doubtless be grades of work, in some of which the study of the more scientific sides of the question will be more necessary than in others.

The subject of illumination contains many questions of the very greatest importance, which though simple in character are none the less scientific, and can be acquired by the present lighting contractors. On the other hand, there are certain scientific aspects of illumination which are also vitally important, but which need only be exhaustively studied by the highly trained and impartial expert whom we desire to see evolved from the existing sections of the engineering profession interested in illumination, who by studying this subject will ultimately become the specialist in illuminating engineering.

For the moment we are chiefly anxious that those simple rules of illumination which are of paramount importance should be generally appreciated and carried out.

By the time that this has been done the less readily evident scientific principles of illumination will have been discussed and their application will have become more generally recognized; we are in no wise anxious to cause confusion by insisting on the general adoption of methods which have yet to undergo thorough practical tests.

Leon Gaster.

In addition to the contributors to our January number and the other British and Continental authorities who have promised to contribute, we may mention the following additional names of contributors who have now promised their cordial co-operation and support:—

Herr Biegon von Czudnochowsky, Mons. Granjon, Dr. F. Jacobsohn, Mons. Laporte, Dr. E. Liebenthal, Herr H. Weber.

TECHNICAL SECTION.

Illumination, Its Distribution and Measurement.

(*Continued from p.* 11.)

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

The Advantages of the Harcourt and the Hefner.—The two rivals at present are the Harcourt and the Hefner, with the Carcel in the background as a venerable relic, and the Violle as an unattained ideal of the future. The advantages of the Harcourt for testing gas are very considerable, since correction of this lamp for variations of barometric pressure, moisture, and carbonic dioxide present in the air, practically cancel out against variations in the light of the gas under test. For accurate work against electric light these corrections must be applied. The ten-candle size of the standard is convenient, the colour of the light is good, and slight variations in the specific gravity of the pentane are not serious. The disadvantages are the importance of the necessary corrections and the large size of the apparatus. The barometric corrections doubtless arise out of the gravity-feed of air-gas, and the action of the chimneys. These, however, and the hygrometric corrections do not constitute a serious disadvantage in a well-equipped laboratory where work of high accuracy is carried on.

The advantages of the Hefner are that it needs considerably smaller corrections than the Harcourt, it is inexpensive, easy to use, is only $2\frac{3}{4}$ inches in diameter, and 5 inches high, and it is widely recognized as a practical unit. The objections to it are the orange colour of the light, and that a one-candle standard is not so useful as a ten-candle.

The Arc Standard.—The idea of screening a flame, and allowing the light from a definitely measured portion to be used as a standard originated with Methven, who screened an Argand gas flame to give one candle or two candle-power. The same system is used in Harcourt's pentane lamp. Violle used a screen with an aperture of one square centimetre. In 1892 Mr. J. Swinburne and Prof. S. P. Thompson independently suggested that a screen having an aperture of one square millimetre should be used with an electric arc, and it was thought that the temperature of the carbon would be uniform, being that of its volatilizing point, and this would cause a standard quantity of light to pass. I had already made a very rough estimate based on a research with a different object.* In that research I was concerned only with relative photometric measurements. These were sufficiently exact for the purpose in view, but the value of the standard was not of importance, and

* *Journal Inst. Elec. Engrs.*, vol. xxi. p. 360.

was not verified. The values 64 to 70 candle-power per square millimetre were deduced from the area of the visible part of the crater or incandescent surface of the positive carbon. I at once attempted to investigate the proposed unit of light, and at about the same time, M. A. Blondel conducted a similar but independent research.

A little study of a well-focussed image of the crater of a continuous current arc, enlarged about 20 times, showed that the brightness of the surface was by no means uniform, and that somewhat erratic changes took place. A bright spot was often seen near the middle of the crater. It was always more noticeable when the arc was humming, but disappeared and was replaced by flashing patches when the arc hissed.

For the purpose of reducing the light by a definite proportion, I used the rotating sector so largely employed by Sir W. de W. Abney, and found that the image on the screen was often covered with shadows connected in some way with the sector. A rotating disc allowing the beam to pass for about 1-1000th of a second, and to be cut off for about 1-100th of a second revealed a bright patch occupying about one-quarter of the crater, revolving about 100 times per second, seldom faster than 450 per second, and difficult to distinguish below 50, though Mrs. Ayrton has observed probably a different kind of patch revolving slowly enough to be seen without the stroboscopic disc.* The maximum brightness was about 170 candles per square millimetre. A fair average is 150.

Circumstances prevented my further investigation of this phenomenon, but it introduced an unexpected and apparently insuperable objection to the use of the proposed standard of light.

Radiation Standards.—Lummer and Kurlbaum in Germany, and Petavel in England have endeavoured to use as a standard the light emitted by one square centimetre of the surface of platinum when raised to such a temperature that 10 per cent. of its radiation would pass through, and 90 per cent. would be absorbed by the thickness of two centimetres of water in a glass cell. The adjustments are difficult. This and the Violle standard seem to share a sort of superior quality, and claims for regarding them as "physical units" have been made on the strength of their dependence on a square centimetre, and a noble metal. The real claim of a standard for recognition must lie in its practical and exact reproducibility. The actual magnitude is of no consequence, since the low mechanical equivalent of light puts a centimetre-gramme-second unit out of the question.

Glow-Lamp Sub-Standards. — While there are practical advantages in using a flame standard such as the Harcourt or Hefner, or even the Carcel, for measuring the intensity of flame-sources of light, electrical engineers and most physicists prefer an electric glow lamp as a practical standard, whatever the ultimate or official standard may be. Dr. J. A. Fleming has given great care to the construction of such sub-standard glow lamps. The difficulty is that secondary sub-standards must be provided and compared with the carefully standardized lamps, for the candle-power will inevitably alter with use. Another drawback is that very exact measurements of electric current must be made, and the source of this current must be a special secondary battery. The expense of the equipment is therefore considerable, and a Hefner lamp will often be found more convenient.

The next quantity to be considered is illumination. When light falls on a surface, that surface is said to be illuminated. The illumination depends simply on the quantity of light falling upon a given surface, and has nothing to do with the colour or reflecting power of the surface; just as rainfall is independent of the nature of the soil. When rain falls on an absorbent soil it quickly disappears, but the water stands on an impermeable soil. Illu-

* *Proc.* Royal Soc., vol. lvi. (June 12, 1894), and Cantor Lectures Soc. of Arts, S. P. Thompson, 1895, vol. xliii. pp. 973-5.

† *The Electrician*, vol. xxxiv. pp. 37 and 77.

mination falling on a dark-coloured surface is absorbed and wasted, while when the same illumination falls on a light or white surface there seems to be "plenty of light." A careful distinction must be observed, for two rooms may have identical illumination, and one may seem to be well illuminated and the other badly illuminated. There is no paradox here—the word "illumination" is properly used, and the word "illuminated" is misleading. It may appear pedantic to prefer the word "lighted" to "illuminated," but when once a word has a well-defined scientific meaning, borrowed though it be from ordinary language, that meaning should be jealously guarded.

When the same illumination falls, say, on white paper and on brown paper the result is, of course, very different; the brightness resulting from illumination has been called luminosity by Sir W. de W. Abney.

Illumination consists of two factors, candle-power and distance. The illumination produced by 1 candle-power at the distance of 1 ft. is the unit recognized in England and America—it has generally been called the candle-foot. It was used by the late Mr. Sugg about 45 years ago.* In France the unit is naturally the carcel-metre, and it has been in use since 1882. During the last few years the name foot-candle has been used in America. Either name is unfortunate, because, unlike all other compound units, such as the foot-pound, the quantity is not the product of candle-power into length, but it is the quotient, and the divisor is not a length in feet, but the square of a length, for the illumination of 1 candle at 1 ft. is equivalent to 4 candles at 2 ft., or 9 candles at 3 ft. The "candle-power-foot" used by some writers is quite unnecessary, and the "candle per square foot" used by others is a confusion for "candle-per-foot-squared" advocated by Carl Hering.† This seems to be a mistaken expression; it can be supported only by the introduction of unnecessary dimensions, for the square comes in arithmetically and not as an area. Many years ago the editor of *Industries* quarrelled with the candle-foot, and suggested, after the fashion of Lord Kelvin's "mho," that it should be called a "candle-toof-toof." There is something to be said for a "candle-at-a-foot," but perhaps the American name "foot-candle" is the best, for twice this illumination becomes "two-foot-candles," and the candles appear to be multiplied, which is not so misleading as "two-candle-feet," where the candle remains single and the foot becomes plural. I objected to the name when I first encountered it, but I propose to adopt it in future, for the reason which is given here. The symbol in writing may clearly be c/f^2.

All this confusion would be avoided by the recognition of a special name for the unit. Sir William Preece, the first engineer in this country to give attention to the measurement of illumination, adopted the carcel-metre, and he showed* that it was equal to a standard candle at 1·058 ft. At the Paris Electrical Congress of 1889 he proposed the name "lux" for this. Owing to the general apathy with which the subject of the distribution and measurement of illumination has been regarded, neither the name nor the unit came into use. But the carcel-metre has been displaced lately in favour of a unit of illumination produced by a Hefner or bougie-decimal at a metre; this has been called a bougie-metre, and the name "lux" was revived at the Geneva Congress of 1896 and was applied to this unit. In such a case, a name gets over the difficulty of a compound word. The lux is, roughly, one-twelfth of a foot-candle, or about one-fourteenth of Sir W. Preece's lux. The foot-candle is a very convenient and comfortable illumination. It is for most people the best illumination for reading, and is to be found on most well-lighted dining-room tables and billiard tables. More than 3 foot-candles is seldom attained in artificial illumination.

* *Proc.* Inst. Civil Engrs., vol. cx., 1894.

† 'Ready Reference Tables,' Carl Hering, p. 148.

* *Proc.* Royal Soc., vol. xxxvi. p. 276. This was based upon 9·6 candle-power for the carcel.

The law of inverse squares* is easy to understand, but the arithmetical application is not so obvious. To say, off hand, how many foot-candles are produced by a sixteen-candle lamp, at a distance of 8 ft., is rather puzzling at first. The illumination is $\frac{16}{8^2} = 0{\cdot}25$ foot-candle. Taking the Hefner at 0·913 candle-power and the metre at 3·28 ft., the lux is $\frac{0{\cdot}913}{3{\cdot}28^2} = 0{\cdot}085$ foot-candle, and the foot-candle is 11·8 luxes.†

These calculations are easily done on a slide-rule. Fig. 4 shows a slide rule with 8 (feet) on the C scale set below 16 (candle-power) on the A scale. Then above 1 on the C scale find 0·25 on the A scale. To find how much candle-power at 5 ft. will produce 0·25 foot-candle, with the rule set as in Fig. 4 over 5 on C find 6·25 on A, or for 50 ft., 625 candle-power.

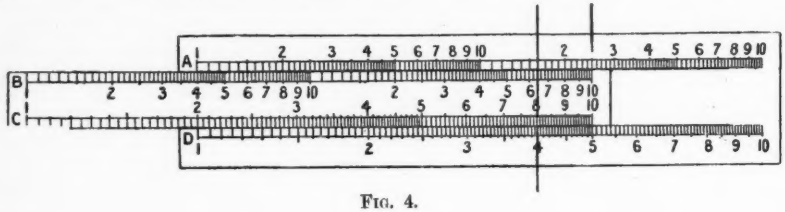


FIG. 4.

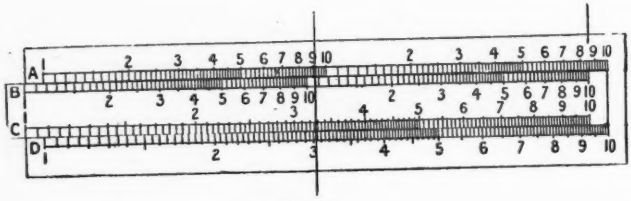


FIG. 5.

Fig. 5 shows a slide rule set with 3·28 (feet = 1 metre) on C, set below 0·913 (candle-power = 1 Hefner) on A. Then above on C read 1 lux = 0·085

* The explanation of the law of inverse squares given by Mr. J. W. Dibdin in his 'Principles of Photometry' (p. 15) can hardly be improved upon:—

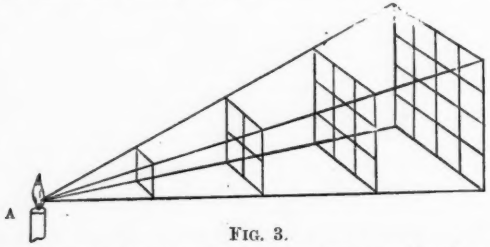


FIG. 3.

"Let it be assumed that the four diverging lines enclose a number of rays of light proceeding from the radiant A. At a distance of one foot, the whole of these rays would fall upon a screen of small dimensions. At twice the distance they would illuminate a surface four times the size of the first screen; and consequently the volume of light impinging upon a screen the same size as that at one foot distance would be only *one-fourth*. At three feet distance, the whole of the rays would have spread, so that a screen nine times the size of the first would be required to arrest them all, and therefore our small screen, if removed to that position, would receive only *one-ninth* of its primary illumination.'

† With the old value, Hefner=0·88 c.p., the lux is 0·0818 foot-candle, and the foot-candle 12·2 luxes.

foot-candle, and below 1 on A read 1 foot-candle = 11·8 luxes.

The foot-candle, as already defined, assumes that the illuminated surface directly faces the source of light. If the surface is inclined to the direction of the rays of light, the illumination will diminish in proportion as the projected area of the surface diminishes when viewed from the source of light. The visible surface varies from unity, as seen full, to nothing when seen on edge. It is a well-established convention among writers on optics (but it is only a convention) that the inclination between a ray and the perpendicular to a surface shall be called the angle of incidence. This angle will frequently be alluded to, and will be designated where necessary by θ. A ray proceeding horizontally, parallel with the ground, will therefore be of 90° incidence, and a ray falling on the point immediately below a lamp will be of 0° incidence on the horizontal plane beneath it.

Let a parallel beam of light pass through a hole AB (Fig. 6) 1 ft. square, and fall on a screen CO parallel with

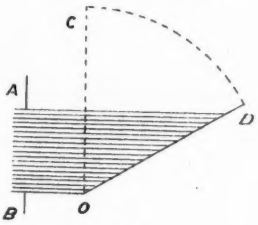


FIG. 6.

the screen AB, and perpendicular to the direction of the beam, that is, with angle of incidence 0°. Let the value of the illumination on CO be called 1. Then let the screen be tilted through 60° to the position DO. It is evident that the illuminated area on the screen is increased from 1 square foot to 2 square feet. The illumination being spread over twice the area, the value is therefore one-half. The angle of incidence is 60°; the cosine of 60° is 0·5; turn the screen through another 30° to OE, or through a right angle with its first position; the light passes by, and theoretically none falls on the screen; the illumination is 0; the angle of incidence is 90°; the cosine of 90° is 0.

In Fig. 7 let AO, BO, DO, FO, and HO be successive positions of the screen.

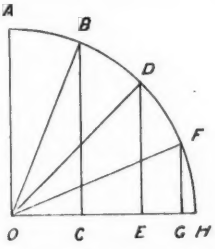


FIG. 7.

Let BC, DE, FG be perpendiculars dropped from the points B, D, and F. Then AO being unity, these perpendiculars measure the cosines of the angles through which the screen is turned, and are proportional to the illumination of the screen. Another aspect of this is to consider how the area of the screen, as seen from the direction in which the light falls, diminishes. It is unity at AO, and becomes zero at OH.

The table on page 11 was an attempt to express the values of the three standards in candle-power. It is better, perhaps, to arrange the table as follows, giving the simple relation between the standards :—

	Carcel.	Harcourt.	Hefner.
Carcel ...	1	0·98	10·75
Harcourt ...	1·02	1	10·95
Hefner ...	0·0932	0·0913	1

(To be continued.)

On the Efficiency of the most Common Sources of Light.

By Dr. H. Lux.

(Communication from Dr. H. Lux's Laboratory for Lighting Technics.)

As is well known, only a relatively small fraction of the energy expended in the production of artificial illumination is actually converted into light, the greater part being converted into invisible rays, principally of great wave-length, and usually, though incorrectly, termed "heat rays." The rays of very short wave-length, the ultra-violet rays, which also occur, play but an inferior part quantitively, and may therefore usually be disregarded.

Since, in the production of artificial light, the occurrence of invisible rays of great wave-length is equivalent to waste of energy, it is naturally of great importance in lighting technics to determine the ratio of the visible to the invisible rays. The figures given by various authorities for this ratio, however, differ very essentially, this being due principally to the different methods of research. In most experiments the total radiation of energy by the various sources of light has been determined, and the ratio of the light-giving radiation to the total radiation calculated from the Angström mechanical equivalent of the unit of light and the average spherical luminous intensity. In proceeding according to this method, it has been assumed that the equivalent of the light-unit determined by Angström with a Hefner lamp is a constant physical quantity, somewhat in the same manner as the mechanical equivalent of the heat-unit. The values for the ratio of the light-giving radiation to the total radiation calculated in this manner, however, differ so greatly from the values obtained in various other ways, that the results of the several experiments can scarcely be compared with each other. The greatest differences are those between the values obtained by Prof. Wedding and the values arrived at with the aid of Angström's equivalent.

For this reason I determined to test systematically the most important of the sources of light at present in use, and to ascertain both the total radiation and the light giving radiation by absolute measurement. The radiant energy was measured by means of a Lummer-Kurlbaum bolometer, which enables even the smallest amounts of radiated energy to be detected and measured absolutely. I give seven different methods — three of them original—which, generally speaking, all yield the like good results. In each case the altered bolometer-resistance due to rays being cast upon the bolometer is compared with the like alteration of resistance of the bolometer brought about by a measurable electric current. The measurement of the total radiation, *i.e.*, the radiated energy of all wave-lengths, presents no difficulty.

The difficulties presented are necessarily greater, however, when it is a matter of determining the quantity of radiated energy within the range of the visible part of the spectrum, *i.e.*, of the radiated light. This arises, firstly, from the fact the amounts of radiated energy are extremely small —amounting to only one-millionth of a watt in any given direction of radiation; and, secondly, from the fact that is is extremely difficult, physically, to separate the visible

Source of Light.	Consumption of Energy.	Total Spherical Radiation.	Spherical Light Radiation (between 0·4 and 0·8 μ wave length).	Ratio of Light Radiation to Total Radiation.	Ratio of Light Radiation to Consumption of Energy.	Mean Horizontal c.p.	Mean Spherical c.p.	Watts consumed per mean Spherical Hefner Candle.	Energy equivalent of one mean Spherical Hefner Candle.
	Watt.	Watt.	Watt.	Per Cent.	Per Cent.	H.K.	H.K.	Watt. / H.K.	Watt. / H.K.
Hefner lamp	86·3	9·96	0·089	0·89	0·103	1	0·825	104·6	0·108
14-inch Petroleum lamp* ...	508·0	102·2	1·26	1·23	0·25	14·2	12·0	42·3	0·105
Acetylene flame†	96·0	9·78	0·62	6·36	0·65	7·7	6·04	15·9	0·103
Incandescent gas light :—									
(*a*) Vertical,									
without chimney ...	716·7	147	3·28	2·26	0·46	107	89·6	7·98	0·037
with chimney ...		112·1		2·92					
(*b*) Inverted,									
without globe ...	571·0	143	2·9	2·03	0·51	107	82·3	6·97	0·035
with globe		97·6		2·97					
Electric carbon filament glow lamp with globe	98·23	63·3	2·03	3·2	2·07	31·5	24·5	4·09	0·085
Ditto without globe		75·2		2·7					
Nernst lamp without reducing-rheostat	165·0	122·2	6·96	5·7	4·21	120 1	94·9	1·74	0·073
Ditto with reducing-rheostat	181·4				3·85			1·91	
Tantalum lamp‡	44·0	25·2	2 15	8·5	4·87	34·6	26·7	1·65	0·080
Osram lamp‡	38 3	22·5	2·05	9·1	5·36	36·3	27·4	1·43	0·075
Direct current arc lamp	435·0	301·8	24·3	8·1	5·60	190	524	0·83	0·047
Ditto enclosed arc	541·0	308	6·2	2·0	1·16	200	295	1·31	0·021
Flame arc lamp, yellow light ...	349·7	295	46·2	15·7	13·20	907	1145	0·31	0·041
Ditto white light ...	348·0	304·5	23·2	7·6	6·66	602	760	0·46	0·031
Alternating current arc lamp ...	180·6	91·2	3·4	3·7	1·90	109	89	2·03	0·038
Uviol mercury vapour lamp§ ...	198·6	91·3	5·3	5·8	2·24	437	344	0·58	0·015
Quartz lamp	691·0	236·0	41·5	17·6	6·00	3400	2960	0·23	0·014

* Consumption of petroleum per hour, 39·73 grammes; heat of combustion of the petroleum, 11050 gr. cal. The total radiation was measured without chimney.

† Consumption per hour, 7·2 litres; heat of combustion, 13900 gr. cal. per litre.

‡ In calculating the total radiation, the absorption by the glass globe, amounting to about 15·5 per cent., was not estimated.

§ Uviol lamp of Schott & Gen., about 90 cms. long; average P.D., 63 volts; average current, 3·3 amperes. For the average spherical luminous intensity the formula $J_0 = \frac{\pi}{4} J_h$ was employed. The value of the total radiation is surprisingly low compared with the consumption of energy. This is probably due to a great proportion of the energy expended being used in vaporising the mercury.

radiation from the total radiation in the same manner as is done physiologically by the eye. I discovered, eventually, that a concentrated solution of ferro-ammonium sulphate in a layer 10 cms. thick yields the best results. This method, at any rate, gives results for the Hefner lamp and the acetylene flame coinciding almost exactly with the results obtained by Angström in an entirely different manner. Thus, Angström found the equivalent for the total light-giving radiation of the Hefner lamp in space to be 0·102 watt, whilst I have arrived at the value 0·108 watt. In view of the difference in the conditions of experiment this may be regarded as almost perfect agreement. It can, therefore, be assumed that the equivalents of total radiation and light-giving radiation ascertained by me for the various other sources of light are reliable as respect serial order.

It will suffice here merely to tabulate the results of my experiments.*

As is seen from the table, the various sources of light are divided into four main groups, which differ very distinctly from each other. The first group includes those luminous sources which have an exposed flame. The least economical of these are the sources in which finely divided carbon is brought to a state of incandescence.

But in the case of the incandescent gaslight, also, the efficiency is exceedingly low, since the energy supplied is chiefly utilized to bring the nitrogen of the air to a higher temperature, so that more than two-thirds of the energy expended is absolutely lost as far as illumination is concerned.

The employment of the heating-effect for the production of light is a very circuitous method, even when the electric current is used for heating the illuminating bodies. But with the aid of the electric current it is, at all events, possible—even though at present only theoretically—to improve the ratio of light-giving radiation to the energy expended very considerably by simply increasing the temperature. With the employment of flames—however hot—on the contrary, there is no real improvement possible, even if radiating bodies were to be used which radiate still more selectively than the Welsbach incandescent mantle.

An opinion can be formed respecting this fact, if the values for the energy expended shown in the above table are compared with the total radiation measured. The values ascertained for the luminous sources of the first and second classes, that is, for sources with open flames and the various electric incandescent lamps, are especially instructive. It will be seen that with the sources with open flame only a minute fraction of the energy expended is converted into radiant energy. A substantial elevation of the temperature would, it is true, bring the maximum of radiation into the visible range, but even in the most favourable case, only about 20 per cent. of the energy supplied could be converted into light. It is far simpler to attain more economical production of light by the employment of the Joule heat. As the values of the energy supplied and total amount radiated in the case of the electric incandescent lamps make clear, a very considerable portion of the energy expended is obtained again in a radiant form.

In the case of the Tantalum and Osram lamps the losses are only apparently greater than in the case of the carbon filament and the Nernst lamps; the amount of the radiation absorbed by the glass globes used with the metallic filament lamps could not be estimated. In reality these lamps do not behave essentially differently from the carbon filament lamp, where about 15·5 per cent. of the total radiation is absorbed by the glass globe, *i.e.*, about three-fourths of the energy expended is converted into radiant energy. An increase in the temperature of the illuminating body would alter nothing here, except that the radiation would be of another *quality*. It might enable the total radiation to consist chiefly of luminous rays, and not, as at present, mainly invisible energy. In this manner the yield

* A full report of my investigations will be found in the *Zeitschrift für Beleuchtungswesen*, 1907, No. 16 *et seq.*

of light could be increased to about 60 per cent. and more. The great improvement in economy, which is rendered possible by raising the temperature, is shown by the performances of the metallic filament lamps, the greater efficiency of which, as compared with the carbon filament lamp, is mainly due to the higher temperature of the incandescent metallic filament. This is shown still more clearly by the well-known experiment of overrunning a carbon filament lamp.

The problem which remains to be solved, therefore, is to find a material which can withstand continuously a temperature that the present carbon filament lamp can only bear for a few seconds. For the solution of this problem metallic filamens, even of the most refractory metals, would appear unsuitable, since their melting points must set a limit. It would seem that only a carbon filament could withstand the necessary high temperature permanently. Naturally such a carbon filament would have to be absolutely homogeneous, in order to avoid the disintegrating action following the liberation of occluded gases.

In any case, it is more difficult to bring the economy of the pure temperature-radiators to a higher stage, on account of the essentially circuitous method, than to obtain light-vibrations from the electrons by direct excitation. In the case of those sources of light in which the luminosity is not pure temperature-radiation, but is, to a very great extent, the result of luminescence, we approach the solution of the problem. Among luminous sources of this class may be mentioned firstly, the mercury vapour lamp, and, secondly, electric arc lamps, especially those in which incandescent gases or metallic vapours are intentionally brought to a state of luminosity. The enclosed arc and the alternating small current arc, it is true, are at present less efficient than the metallic filament incandescent lamp, so that attempts to attain success by these means do not appear encouraging.

On the other hand, the ordinary direct current arc lamp and, in particular, the mercury vapour Heræus Quartz lamp are more efficient. From the above table we see the degree of efficiency of these sources of light—even to-day where we are just at the commencement of their development—is very high. Compared with the economy of the ordinary petroleum lamp, which is still by far the most universally used illuminating apparatus, an arc lamp with yellow-flame-carbon is an immense advance. The efficiency of the former is but 0·25 per cent.; while that of the latter is as much as 13 per cent.—that is to say, 52 times as much! It is remarkable that with the present means at our disposal, it is possible, even now, to bring the economy of light-production almost to the same level as occurs in the conversion of one form of energy into another, in the steam engine.

Ceteris paribus, therefore, those sources of light must be held to be the most advantageous which do not depend mainly upon pure temperature radiation, until recently the only method at our disposal. From this point of view those values in the above table, which afford information respecting the mechanical equivalent of light for the various luminous sources, are of special interest.

The assumption sometimes met with in the literature of the subject—that the mechanical equivalent of the light-unit must be a constant quantity for all sources of light—would, in view of the present investigations, appear to be no longer tenable. It is also obvious that the value of the mechanical equivalent of light must depend upon the spectral composition of a source, and the differences in the effective values of various sources, even belonging to the same category, can, perhaps, be explained in this way.

But another remarkable fact is brought out by the figures in the last column of the above table. The sources of light — in which finely-divided carbon is rendered incandescent, and also the electric glow-lamps,

have an energy-equivalent for the average spherical light-unit which is approximately equal to 0·1 watt H.K. These are the pure temperature-radiators. In the case of the electric arc lamps, on the contrary, we find values which average about 0·04 watt H.K.; and in the case of the mercury vapour lamp, yielding a pure line-spectrum, this value even sinks to 0·014 watt H.K. Those sources of light which involve luminescence-effects therefore require less than one-half the expenditure of energy that is requisite in the case of pure temperature-radiators.

This appears quite reasonable, if the mechanics of illumination be regarded on the electron theory. We may note, too, the bearing on the theory of the Welsbach mantle, of the fact that the energy-equivalent of the incandescent gaslight ranks with that of the electric arc lamps. The peculiar composition of the Welsbach mantle, therefore, seems to admit of electron-vibrations being excited by pure heat-effect to an extent that is otherwise only possible by the aid of electrical stimulus. The undeniably strong selective radiation of the Welsbach mantle, at any rate, does not alone suffice to explain the extremely low value of the energy-equivalent of the incandescent gaslight.

The Cost of the Common Illuminants.

(From *Lumière Electrique*, Jan. 11, 1908.)

A WRITER in *Lumière Electrique* quotes some results of Prof. H. Dörr, of Frankfort-on-Main, relating to the cost of a wide number of illuminants ranging from the candle to the flame arc.

Other figures of this nature have been previously published, and naturally the results of different workers depend both upon the local conditions and the assumptions made by him in the course of his investigations. In order to be complete such results should include the complete details of cost of lamp itself, recurring cost of energy, or fuel, and cost of renewal and maintenance generally.

The results of Prof. Dörr's investigations are included in the table given below, in which the illuminants are arranged in order of cheapness, should be of interest for purposes of comparison:—

COST OF 10 CANDLE-POWER-HOURS.

Type of Lamp.	Cost (centimes).	Type of Lamp.	Cost. (centimes).
Petrol (under pressure)	0·12	Alcohol Lamp	1·00
Flame Arc	0·20	Alternating Arc Lamp	1·00
Mercury Arc	0·31	Nernst Glow ,,	1·06
Incandescent Mantle (gas)	0·31	Miniature Arc ,,	1·12
,, ,, (petrol)	0·50	Acetylene	1·50
Osram Glow Lamp	0·62	Carbon Filament Glow Lamp	2·00
Petroleum	0·87	Gas (round burner)	2·00
Osmium Glow Lamp	0·94	,, (batswing)	3·00
Tantalum ,, ,,	1·00	Wax Candle	13·7

In these calculations the cost of electrical energy was taken as 62 centimes (6·2 pence) per unit. Also the cost:—

Per cubic metre of Gas,		20 centimes.	
,, kilogram	,, Petroleum	27	,,
,, ,,	,, Alcohol	50	,,
,, cubic metre	,, Acetylene	1 fr.	50.
,, ,, ,,	,, Stearine	1 fr.	85.

The order of the illuminants given above differs in several respects from that of other authorities (*e.g.* Prof. Wedding).

Many people will also be at first surprised to find that the candle proves to be the most expensive of all sources of light, until it is remembered that these results are worked out on the basis of "cost per amount of light yielded."

The Production and Utilization of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 31.)

METHODS OF LIGHT PRODUCTION.

All methods of producing light being reduced to the stimulation of electron vibrations, it follows that they may differ in the method of stimulation and in the nature of the substance stimulated. The first method of producing the requisite stimulus is by the chemical methods, in which a substance is burnt, or oxidized, or undergoes decomposition. In this case what takes place is that the atoms of the combustible material and those of the oxygen in the surrounding air have a strong chemical affinity or electrical attraction for one another, and when they come within a sufficient range, under the action of heat, this attraction causes the atoms of the two substances to rush together, thus giving the necessary agitation to the electrons. The nature of the vibrations or radiation given out, however, varies with the nature of the substance burnt. When pure hydrogen burns in oxygen, for instance, there is a most intense agitation, but the vibrations are nearly all outside the limits of vision, and the flame therefore emits very little light. By introducing a solid substance into the flame, these agitations are communicated to it, and we get the continuous spectrum or white light, if the temperature is sufficiently high. The solid substance may be either in the form of carbon particles disengaged from the fuel itself during combustion, as in ordinary candles, oil lamps, and gas flames; of particles of highly refractory materials introduced into the flame, as in some of the recent attempts which have been made in Germany to improve the efficiency of oil or gas flames; or of solid envelopes or bodies, as in the Welsbach mantle or lime light.

Light is also produced when some substances, such as phosphorus, are slowly oxidized, and when disintegration of complex molecules takes place automatically, as in radium. In the case of radium it is well known that electrons are continually shot off resulting in a chemical change of the radium into helium, argon, and lead, but whether this shooting off is the result of intense kinetic energy in the atom, as surmised by Sir Oliver Lodge, or of static or potential energy like the explosion of a shell, as Lord Kelvin believes, is still a moot point. In neither of the latter cases has the efficiency of light production been determined, but up to the present the amount of light has been too small, and in the case of radium far too costly, to be considered. The production of light directly by chemical combustion or disintegration may be termed chemical luminescence. It is probably the origin of the light of the glow-worm and fire-fly, and deserves serious investigation.

The second method of producing light is by electrical means, which may be employed either to produce incandescence or luminescence. In the former the current is passed through a filament of high resistance, and as an electric current in a conductor is simply a passing on of electrons from one atom to another, as fire buckets are handed on (to use Sir Oliver Lodge's analogy), this is accompanied with agitation of the atoms and emanation of heat. As the current strength is increased the agitation becomes more and more rapid until the electrons of the filament are stimulated to the extent of giving light, which is of the usual continuous character of the solid body, and is accompanied by considerable waste heat

radiation. In gases, however, it is now known that the passage of a current is of a different character from that in a solid conductor. In all gases and non-conductors considerable force appears to be necessary to separate their constituents, and in consequence a high P.D. can be maintained between two electrodes a short distance apart without any passage of current. The gaseous molecules in the field between the electrodes are thrown into a state of strain, the positive constituents being attracted towards the negative electrode and the negative constituents towards the positive electrode, but without any separation. When the electric force exceeds a certain amount (about 30,000 volts per cm. at ordinary pressure), however, the atomic forces are overcome, and the charged ions fly towards their attracting poles, forming what is termed an arc. In their passage the charges of opposite sign frequently unite for an instant, and are then hurried on again, causing intense atomic vibration and evolution of heat, which when communicated to the carbon electrode renders it intensely incandescent. The greater brilliancy of the positive carbon is probably due to the much greater velocity of the particles projected from the negative pole, which have therefore a longer free path, and crowd the atomic conflict near to the positive pole.

When, however, a gas is enclosed in a tube and is reduced in pressure, its resistance to the passage of the current is decreased, owing to the reduction of the number of resisting molecules, and the discharge can be maintained over a long tube with a moderate P.D. The longer free path of the separated atoms or ions, and the consequent more sudden impact when they collide enables the gas itself to be made luminous; and, as the pressure is further reduced, the free vibrations are very little interfered with by the collisions, and a light having fine spectrum lines is obtained, as in the Geissler tubes, mercury vapour lamp, &c.

Upon still further exhausting the tube few molecules or atoms are left to vibrate or collide, and we then reach the state known as the Crookes vacuum, when showers of electrons are projected off the negative electrode with a velocity of about 30 millions of metres per second, and drive any residual gas back. These particles do not collide and are quite invisible, but whenever they fall upon a substance they set its electrons into intense vibration, as a shower of rifle bullets fired against a bell might ring it loudly without setting it swinging, or a rapidly moving comet might disturb the planets of the solar system without greatly affecting the sun; and we then have the phenomenon of luminescence, in which the body appears to glow, but with a much more restricted spectrum than is obtained by heating or atomic bombardment, and consequently in many cases with a much more efficient light.

Since light consists of electromagnetic oscillations of a definite range of frequency, the most perfect method of producing it would theoretically be by obtaining alternating currents of this frequency. Hitherto, however, the highest frequencies procurable have been enormously below that required, and so far as can be seen at present there is no possibility of producing such currents directly.

Lastly, light can be produced by what may be termed transformation and storage methods.

Just as a structure is known to quiver with a relatively high frequency when agitated at a lower frequency, like a pier in the sea, when struck by waves, so we have substances which when stimulated by heat or low frequency vibrations, will transform them into high frequency vibrations of light. This phenomenon is known as calorescence, and is perhaps made use of in the "flame" arc lamp.

On the other hand, rapid vibrations may induce slower ones, as is evidenced by the slow heavings of a ship induced by waves of higher frequency, so rapid vibrations of ultra-violet light may induce lower visible vibrations. This phenomenon, known as fluorescence, has already been useful in extending the spectrum of the mercury vapour lamp, and may very likely be of further value

in the near future, although its immediate application is not yet apparent.

Again we have substances which when stimulated in one of the foregoing ways continue to give out light after the stimulus has ceased. Substances of this nature are termed phosphorescent bodies, of which calcium sulphide, the basis of luminous paint, is one of the best-known examples among chemical substances.

The following classification shows in compact form the various ways by which light may be produced, and indicates the avenues of future research and development :—

PRODUCTION OF LIGHT.

CLASSIFICATION OF METHODS.

1. *Nature of Stimulus.*

A. Ionic or atomic impact (large mass, low velocity)		Incandescence	Long spectrum or great range of forced vibrations.
B. Electronic impact (small mass, high velocity)		Luminescence	Shorter spectrum or freer vibrations.
C. Etherial vibration	slow	Calorescence	
	rapid	Fluorescence	

2. *Origin of Stimulus.*

Chemical	(*a*) Rapid combination (combustion or flame)		Incandescence	Self-luminous— Particles in gas, candle, lamp, &c.
				Non-luminous— Particles injected.
				Mantle.
				Solid body (lime light).
	(*b*) Slow combination (oxidation, &c.)		Chemical Luminescence	Phosphorus.
	(*c*) Disintegration (radio activity)			? Glow worm and fire fly
				Radium.
Electrical	(*d*) Conduction		Incandescence	Glow lamp.
	(*e*) Bombardment	Ionic	Incandescence	Arc lamp.
				Geissler tube.
				Mercury vapour lamp.
		Electronic	Luminescence	Crookes tube.
				Luminiscent lamp.
	(*f*) Oscillation			No example.
Radiation (Etherial vibration)	(*g*) Heat (Transforming up)		Calorescence	Fluorspar, &c.
	(*h*) Light (Storage)		Phosphorescence	Calcium sulphide, &c.
	(*i*) Ultra-violet (Transforming down)		Fluorescence	Uranium glass.
				Fluorescine, &c.

In what follows, some attention will first be given to the history of artificial lighting, and to optical, photometric, and radiation measurement. Afterwards these various methods of light will be considered in detail.

(To be continued.)

The History of Illumination up to the Discovery of the Incandescent Mantle.

By Dr. C. Richard Böhm.

The degree of culture attained by a people is indicated by, among other things, their need for illumination.

Since the days when the legendary Prometheus stole the divine fire from heaven, and the earth thus became acquainted with its warming and illuminating properties, illuminating flames were for long regarded rather as objects of religious veneration than as means of illumination, according to our modern sense of the word.

Wood naturally suggested itself as one of the very simplest sources of illumination, especially the resinous pine, which was known and used not only in the times of Homer, but well on in the middle ages, either in the form of isolated splinters or in the open fireplace. Indeed, in many mountainous districts it was so used even at the commencement of the previous century. The next step was the utilization of resin in torches and vessels, and ere long fats and oils, too, came to be used for this purpose.

Oil-lamps occur even in the most ancient Roman illustrations. Great care was bestowed upon the artistic design of these lamps, but the illumination yielded by them was very poor.

We are told that the illumination of temples, palaces, streets, and so forth was considered a great luxury by the various nations that formerly inhabited Asia and Africa, such as the Medes and Persians, the Assyrians, and the ancient Egyptians. In Memphis, Thebes, Babylon, Susa, and Nineveh special festivals were celebrated by the placing of stone or bronze vases at short intervals in the streets. These vases were filled with liquid fat to the weight of 100 pounds or more, the contents being burnt by means of a wick three inches in thickness.

The records of Pliny and Livy also state that, in the case of funerals, reeds soaked in oil were commonly burnt; here we perceive the beginnings of candle-illumination.

The ancient Greeks were unacquainted with candles, but the Romans of this time already distinguished between those composed of wax and those of the tallow variety, and described their manufacture with wicks.

Wax candles seem to be of Phœnician origin. The Phœnicians bleached wax and constructed candles of it, and they seem to have introduced these into Byzantium. In the fourth century A.D., the emperor Constantine the Great is said to have illuminated Byzantium on Christmas Eve with lamps and wax candles. Under the Turkish rule the art of candle-illumination seems to have been almost lost. Candles are first heard of again in the twelfth century and onwards, when they were used in connexion with the services in Roman Catholic churches, and, subsequently, after the Reformation, to a great extent at court festivals.

Until the last century the manufacture of candles remained essentially the same as a thousand years ago. About the end of the eighteenth century endeavours were made to obtain a harder and less easily molten material from the crude tallow, which was first partially thickened and then pressed out, without, however, obtaining the desired result.

The chief objection to the tallow candle was the wearisome "snuffing" or breaking away of the wick, the necessity for which Goethe had already bemoaned in his whimsical way. This defect was first remedied through the discovery of the stearine candle, which

is, in a great measure, due to certain French *savants*, and especially the distinguished chemist, Chevreul. In his famous work 'Recherches Chimiques sur les Corps gras d'Origine Animale' in 1823 he showed that fats consisted of compounds between the then previously known glycerins with the fatty acids. Under pressure he separated out the so-called "stearine."

The practical utilization of stearine was rendered possible by the conclusion of a series of purely technical researches by an Englishman named Milly; to him, indeed, is due the ultimate development of a satisfactory article and also the preparation of the wicks in such a manner to do away with the necessity for snuffing.

In the middle of the previous century the animal and vegetable oils began to be replaced by mineral products. Caucasian "earth-oil," or naphtha had long been known to exist. It was known, too, that very serviceable oils for purposes of illumination (such as paraffin, photogen, solar oil, &c.) could be prepared from the brown and richer varieties of coal. After this was realized greater attention was paid to naphtha. In 1857-the sinking of a bore in Pennsylvania gave rise to the "earth-oil" characteristic of that district, and in this way sprang up the great petroleum industry—one of the greatest industries in the world. Now for the first time satisfaction awaited the old demand—"More light!"

The value of petroleum to mankind as a whole can be judged from the fact that in 1899 the entire world consumed 180 million hectolitres of this product, of which 100 came from America alone, and the remainder principally from the Caucasus.

Meanwhile, great improvements in the construction of lamps kept pace with the spread and cheapening of liquid combustibles. By reason of its mobility and its affinity for cotton thread, petroleum easily rises in the wick, so that it was now possible for the first time to place the oil-reservoir beneath the burner, and to do without the aid of any mechanical contrivance for this purpose. Wicks were also improved, a flat, band-shaped variety, which presented a greater surface of flame to the surrounding oxygen, being now utilized. But the most decided advance ensued through the invention of Aimé Argand, who introduced the ring-shaped wick, which allows the oxygen to have access to the inside in such a manner that both sides of the flame are fed from the surrounding air.

We may also note the further invention by Argand of the glass chimney, which permitted a much greater flame-temperature without the lamp smoking. Argand's invention dates from the year 1783, but its practical application only became evident much later, after the introduction of light oils; still, even previously, this invention had exercised a considerable influence on the improvement of illumination with the fatty oils. The researches of Carcel (1800) were also of value in this respect.

In 1836 the oil lamp reached a high point of economical perfection in the Franchot "Moderateur" type, which almost completely replaced the Carcel lamp, and up to the discovery of petroleum in 1857 found very wide application.

Soon after the introduction of the chimney attempts were made to give it a more serviceable form. Benkler, a tinker of Wiesbaden, was the first to realize that the action of the chimney can be improved by forcing the rising column of air to come into more intimate contact with the flame-surface. He attained this end by narrowing the chimney in the neighbourhood of the flame, a practice which is common at the present time.

Street-illumination was first introduced in Paris towards the end of the fifteenth century, but was then very deficient; subsequently cauldrons of lighted pitch or pine were utilized in 1558, while in 1667 lanterns having a regular period of burning were introduced. Arrangements similar to those obtaining in Paris were afterwards introduced at The Hague in 1618, in Amsterdam in 1669, in Hamburg in 1675, and in Vienna in 1687. In Berlin the Grand Duke introduced the first street illumination, and Frede-

rick the Great in so far improved this that he ordered the erection of 2,470 chandeliers in the place of the single hundred previously existing. In London the streets were first regularly illuminated from 1736 to 1739 onwards.

It was only towards the end of the eighteenth century, with its accompanying violent political, technical, and industrial developments, that scientific chemists had been able to form for themselves a correct conception of the nature of the processes of combustion; thus was laid the foundation of deliberate improvement in the practice of flame-illumination.

One cannot describe the condition of illumination at the end of the eighteenth century more strikingly than by quoting Goethe's couplet :—

Wüsste nicht was sie Besseres erfinden könnten'
Als wenn die Lichter ohne Putzen brennten.

(He could not imagine anything better to invent than that lights would burn without snuffing.)

But already a new method, gas-lighting—the flame-light with no wick —was looming on the horizon, of the existence of which Nature had already hinted in the holy fire of Apcheron near Baku, and the burning well at Wigan in England. The latter phenomenon, in particular, had induced Prof. Becher, of Münich, to attempt the distillation of gas from peat and coal, and by so doing to produce the so-called "philosopher's light." In 1789 Clayton, in 1786 Lord Dundonald, and almost simultaneously that enterprising Scotchman William Murdoch, began to experiment. It was Murdoch who first realized the industrial aspect of illuminating-gas in its entirety, and it was he who first succeeded in bringing the process of the dry-distillation of combustibles to a practical stage.

Towards the end of the eighteenth century Murdoch associated himself with the great improver of the steam-engine, James Watt, in this work. The two great inventions which have exerted the greatest, most far-reaching influence on our daily life issued together from the same spot—the factory at Soho, Birmingham—at the commencement of the new century. Simultaneously with the improved steam-engine, the first gas-lighting installation found its way into the spinning and weaving factories of England.

The year 1792 has been termed the birth-year of gaslighting, for in that year Murdoch installed a gaslighting installation in his own house at Redruth. The success of this installation induced him to embark on wider schemes, with cheerful conviction of ultimate success. In 1798 the factory at Soho was illuminated, and in 1802 the whole front of the factory blazed most effectively with home-generated gas, in honour of the Peace of Amiens. Murdoch erected many gasworks in England, and induced Watt's pupil, Clegg, to take up the subject; he may, indeed, be considered the father of gaslighting.

Simultaneously with the efforts of these men in England, the French engineer, Phillip Lebon, attempted to produce gas from the distillation of wood, but his arrangements seem to have been so unpractical that his invention did not receive much recognition. Lebon lost a fortune in his researches, and was found dead on December 2nd, 1804. His attention having been attracted by these researches, Joh. Winzler of Znaim, in Moravia, investigated Lebon's results, and afterwards travelled through Germany and Austria, provided with a charter from George III., and lecturing upon the discovery of illuminating gas. Eventually he came to London, and in 1810 succeeded in forming the great Chartered Company with a capital of 50,000*l.* sterling.

This company illuminated a portion of London from their works in Peter Street in 1813, lighted St. Margaret's Church in 1814, and eventually secured rights for the whole of England. Winzler and Clegg managed the company for some time, but presently disagreement led to their resignation. Winzler went to Paris, where he introduced illuminating gas in 1817. Clegg continued to build gasworks in England on his own account, and died in 1861, highly respected, at Hampstead.

Besides coal, animal and vegetable oils were ulso utilized for the preparation of gas. Such gasworks were built in 1815 by John Taylor of Stratford. Owing, however, to the high price of raw materials, they did not pay well, and have since all been converted into gasworks of the ordinary variety, just as occurred in the case of the wood-gasworks erected by Pettenkofer in Munich and Riedinger in Augsburg about 1850. In 1850 petroleum was introduced from America into Europe, and about 1860 Heinrich Hirzel of Leipsic and others were induced to study the application of the products of distillation to the manufacture of oil-gas, and the re-ection of oil-gasworks, intended specially for small installations; to-day there are in Germany alone 1,000 such oil-gasworks, which, however, now chiefly utilize paraffin oil and the by-products of the distillation of varieties of coal rich in hydrocarbons.

The first gasworks erected in England, apart from those in London, were in Birmingham, Norwich, Hull, Dublin, and Plymouth; this method of illumination only spread to the continent much later. About 1784 Prof. Winckeler of Löwen had published an account of the discovery of the gaslight, and already in 1786 Prof. Sickel of Würzburg had illuminated his laboratory with gas. In 1816 his example was followed by Flashoff, a chemist of Essen, and in 1818 Dinnendahl so illuminated a workshop in which sixty workers were employed. On April 17th in the same year the first lighthouse was illuminated by gas at Salvore on the coast of Istria. In the following year the lighthouse and beacon at Dantzic were lighted in the same way. The first gasworks was built at Hanover in 1828. On the 19th of September, 1827, "Unter den Linden," in Berlin, was lighted by gas for the first time. Dresden followed suit in 1828, Frankfurt in 1830, Leipsic in 1837, and subsequently many other towns, while in Wurtemberg works were laid down at Heilbron in 1842, and Stuttgart in 1845. By the year 1850 the great majority of the larger German towns had installed gas both for the illumination of the streets and also for the lighting of the interiors of buildings, and after this time the medium-sized towns and even the small towns were also provided with gas.

In place of the at first exclusively and even now most generally employed ordinary coal-gas, gas prepared from wood, peat, and special cannel coal, and, more recently, oil-gas was utilized. At the present time the use of water-gas for illumination, especially in America, has become usual. If there is one material which has been subjected to alternations of approval and dislike, it is water-gas. After being repeatedly almost entirely forgotten, it has invariably attracted a great share of attention as soon as it reappeared in the public eye, and rightly so. The merits of this combustible are indeed so marked that any great progress in the development of water-gas will be noted with very general interest.

The advantages of gaslighting lie in the high intensity of the light yielded and the extraordinary cheapness in comparison with the light-effect obtained. In comparison with oil-and petroleum-lighting the convenience of its application, which arises both from the arrangement of the apparatus of combustion and the almost infinite divisability of gas itself, must also be reckoned to the credit of gaslighting.

For more than half a century flame-lighting, either in the form of oil or gaslighting, reigned supreme. But towards the end of the seventieth year of the previous century the flame combustion, or as it might be termed "chemical" light, began to experience the rivalry of a flameless, combustionless source—the electrical glow-lamp, a struggle between the two methods of illumination ensued, of which we are witnesses at the present day In the course of this competition the world was filled with an abundance of light, of the possibility of which the previous generation had had no conception.

The rapid development of the electrical light led many men of business to believe that it would achieve a complete revolution in illumination, and would not only supersede existing systems, but eventually monopolize

the entire field of public and private lighting. Others, again, were of the opinion that gas-installations would in future be confined to the possibilities of supplying heat and power, but that even from this point of view they rested on a satisfactory and favourable industrial basis.

Through the above-mentioned and similar events the requirements of gas-lighting were promoted, and improvements in the preparation and burning of gas achieved which rendered reduction of prices possible, and were of great value to the public.

Subsequent years saw a remarkable simultaneous development of all methods of illumination; there remained, however, some doubt as to the future of the gaslighting industry, but this was set at rest by the practical arrival of the incandescent mantle.

With the arrival of the mantle gas-lighting entered upon a new period in its development; at the same time the wish of those who had recommended that the gas industry should confine itself to the production of heating gas was also realized.

For the essentially heat-producing Bunsen burner, which has been, in the main, applied to heating and cooking purposes, is also the basis of the new gaslighting. The glowing gas itself has been replaced by a foreign incandescent material—a new "wick," in fact.

The problem of light-production has therefore been reduced to a question of heating. Hence the gas industry is no longer concerned with the utilization of a very restricted, dear, and occasionally only with difficulty procurable variety of coal. Their choice among raw materials is now considerably enlarged. The introduction of the incandescent mantle opens up a wide field for future activities in the departments of gas utilization and production.

The Economical Illumination of Display Windows.

JOHN D. MACKENZIE, A.I.E.E.

"Where there is too much light, our senses don't perceive; they are only stunned or dazzled or blinded."—Pascal.

THE problems which meet the illuminating engineer, and which it becomes him to successfully solve, are very varied. Each successive scheme has some distinguishing feature to differentiate it from its predecessor, whether that be due to some peculiarity of building, decoration, colour scheme, the purpose for which the illumination is desired, or even to the particular idiosyncrasy of the client. It accordingly is necessary to take each case entirely on its own merits, and to reason out the best arrangement for each particular installation if the best results are to be obtained. At the same time it is possible to give some indication of the lines generally successful in any given class of illumination design, and the author will endeavour to do this in the following remarks for that large class generally described as "display windows."

The problems involved in display window illumination show fewer dissimilarities than perhaps in any other class of lighting work, and yet there is scarcely any other so badly handled. Within the last year or two there has been undoubtedly a great improvement; but any one can see what a large field is still open for the intelligent use of some illuminating engineering knowledge. In order to grasp the general principles involved, a study of the necessary conditions to be fulfilled by successful illumination is essential, and hence it will be well to start with a statement of these conditions, and some preliminary reasons for them.

The purpose aimed at in all display window lighting is two-fold, and may simply and tersely be expressed as follows from the shopkeeper's standpoint, namely:—

1. Attract the likely purchaser to *my* window.
2. Rivet his attention *on the goods I wish to sell.*

To achieve this two-fold object it is generally necessary to use two distinct illuminating methods; under certain circumstances one method may be sufficient. In order to achieve the foregoing objective the following conditions must be fulfilled. The illumination—

(1) must be such as to render the premises conspicuous or to arouse interest in the casual passer-by;
(2) must efficiently illuminate the particular goods on show;
(3) must not obtrude harshly on the vision of the prospective buyer;
(4) must not be unnecessarily costly in installation or upkeep.

Before deciding on any particular scheme of illumination some governing factors come up for consideration, and these should all be treated in a commonsense method, without any undue bias. Some of these governing —and often disturbing—factors are as under:—

1. The client.
2. The general illumination of the particular thoroughfare: (*a*) street lighting, (*b*) as to shop lighting.
3. The probable effect the proposed scheme would produce on neighbouring business rivals.
4. The special requirements of the particular case.

1. The first factor in the situation is the *client*, and his desires must always weight heavily in any scheme. Sometimes—though seldom—he gives one a free hand simply to give him "a good light"; but more often he limits first cost of installation and then running cost of consumption. Should the client's limits be insufficient to enable the engineer to give a satisfactory installation, it is then his duty to endeavour to get these limits increased to a reasonable amount, and it is here that one with a full grasp of his subject can prove to his clients the *raison d'être* of his arguments, and by so doing bring the client round to see the necessity of following the engineer's advice.

2. The second factor, namely, the illumination of the thoroughfare, has a great deal of influence on the intensity of illumination which must be reached in order to effectively display the goods in the shop window. And here I may deal with the statement previously made, that to produce the desired results from the shopkeeper's viewpoint requires generally two distinct illuminating methods.

As is well known, the eye is invariably and often unconsciously attracted to the brightest object in the field of vision, and hence it has been the aim of the shopkeeper to endeavour, by means of outside lamps of high candle-power, to obtain high illumination. Again, the eye is quick to notice any unusual or curious object, and the will responds to the visual impulse, and causes the eye to be focussed on such an object; so that not only will a brilliantly lighted portion of an average street attract immediate attention, but a flashing sign or a coloured light—such, for example, as the mercury vapour lamp—even if only of moderate brilliancy and placed in a brightly illuminated street, cause the passer-by to stand and gaze.

Consequently this external, or, as I might call it, the "advertising" illumination can only be attained successfully in two ways: (*a*) by having the most intense, or (*b*) the most unusual illumination in the vicinity.

It is evident that the present tendency in exterior illumination is a striving after "light and more light"; the open type arc lamp is being superseded first by the small globe enclosed arc lamp with its intense white light, and both are being surely ousted by the flame arc lamp with its yellow or orange glare. And so, too, with the gas lamp, the tendency is ever to more intense illumination, and more of it. Soon, however, a halt must be called in this mad rush after intensity of light sources, as already it is having a most deleterious effect on our eyesight. The writer knows of no more painful sensation to the eye—at least, in ordinary daily life—than to be whirled each evening home from business by electric tramcar past the intensely brilliant globes of the enclosed arcs, at present in use by so many warehouses; the yellowish light of the flame arc is not nearly so trying, due, no doubt, to the fact that the human eye can bear a greater amount of yellow light than of any other.

These considerations seem to indicate that we have almost reached the practicable limits of intensity in exterior illumination, and that other and more unusual methods must be adopted in order to entice "the quarry from afar"; but as this would lead into a discussion on illuminated signs and various other devices, consideration must be deferred to some future occasion.

Now, speaking generally, it is necessary to have outside lamps of some kind, depending mainly on the surrounding illumination, to attract the prospective buyer, and the only circumstances in which such exterior illumination is sufficient without any interior lighting is when the windows are dressed with goods close to the glass, or where, if not so dressed, they are bright in colour, and able to reflect back a large proportion of the direct illumination they receive from the outside lamps; such, for example, as a jeweller's window, or one filled with white stationery, notepaper, &c.

Conversely the only cases in which interior illumination will do alone without external aid is when the

thoroughfare is poorly lighted in comparison with the illumination given in the window. At the same time, so much depends on circumstances that no invariable rule can be given.

3. The probable effect which an increased illumination in any one shop may have on the neighbouring rivals is sometimes very difficult to estimate properly, and the only comment which the writer can offer on the point is this, that the engineer should endeavour to make the particular installation he is interested in so effective as to render it difficult for any other to surpass it.

(*b*) Do not strive for an absolutely uniform illumination, so long as the minimum illumination is not too low. This applies particularly to goods with fine detail, and without any high relief.

(*c*) Do not imagine, because a certain number of lamps or burners lighted a jeweller's window quite satisfactorily that the same will do all right for a bootmaker's window of a similar size.

(*d*) Generally speaking, lamps placed high up and well forward towards the front of the window, with the light directed downward and backward, gives the best effect.



FIG. 1.—CORRESPONDING WITH FIG. 2.

4. The special requirements of each particular case. Here, from the very nature of the subject, no general data or opinions can be given; but the following warnings may be of use in preventing needless mistakes in interior window lighting :—

(*a*) On no account place lamps within the ordinary range of vision.

One or two typical instances of the smaller class of shop windows may now be considered.

Fig. 1 shows a hatter and hosier's window, measuring 9 ft. high by 5 ft. wide by 3 ft. deep, dressed fairly close to the glass, and mostly with light

grey to dark grey goods. The exterior illumination is given by two 3-ampere Reason enclosed arc lamps, two in series on 250 volts; the interior lighting consisting of four 30-c.-p. Osram lamps, each backed by an 8-in. hemispherical silver glass reflector at the top of window, and two 26-c.-p. Tantallum lamps—also with similar reflectors—placed about 6 ft. below them, and kept out of the direct line of vision. Here the class of goods displayed may vary from a show of dressed linen shirts and collars to black hats and dark caps, and it is only when a dark class of goods is displayed that the lower lights are necessary. Fig. 2 shows the same window by night, with a 30 seconds exposure at f. 8 on an Imperial Special Sensitive plate. It will be seen that the lower lights are not directly visible, the reflected image of the arc lamps appearing on the silvered back of the reflectors. The

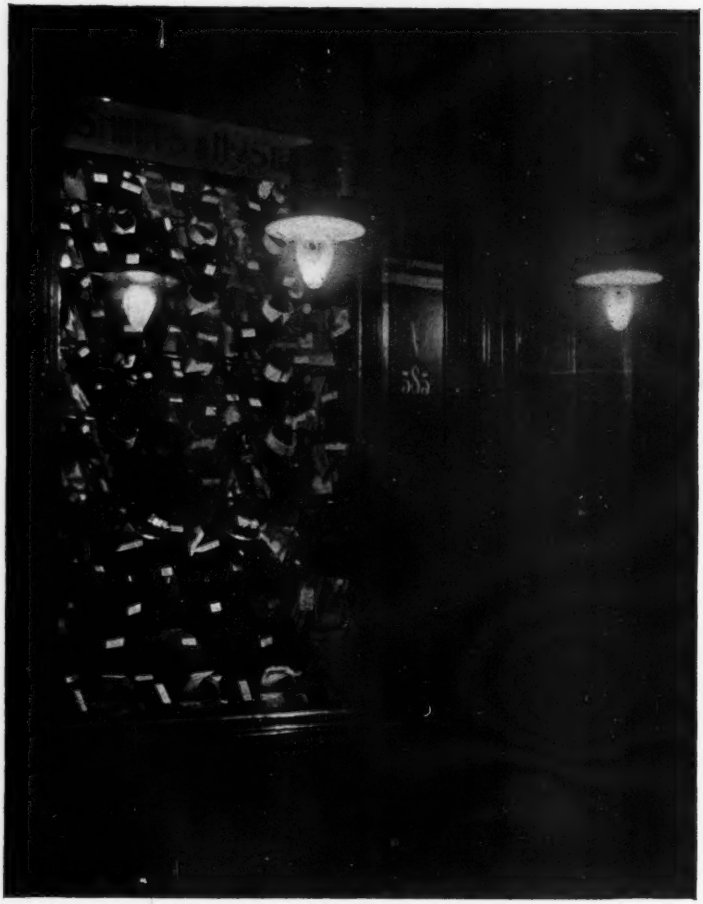


FIG. 2.—SHOWS THE SHOP SHOWN IN FIG. 1, WITH LIGHTS ON, AT NIGHT.

various data and comparative tests appear in the table given below.

Fig. 3 shows a jeweller's window and spectacle show-case, and Fig. 5 a tobacconist's shop.

The premises shown in Figs. 3 and 5 are shown again, lighted at night, in Figs. 4 and 6.

Fig. 4 shows the jeweller's shop which, it will be seen, has no exterior



FIG. 3.—CORRESPONDING WITH FIG. 4.

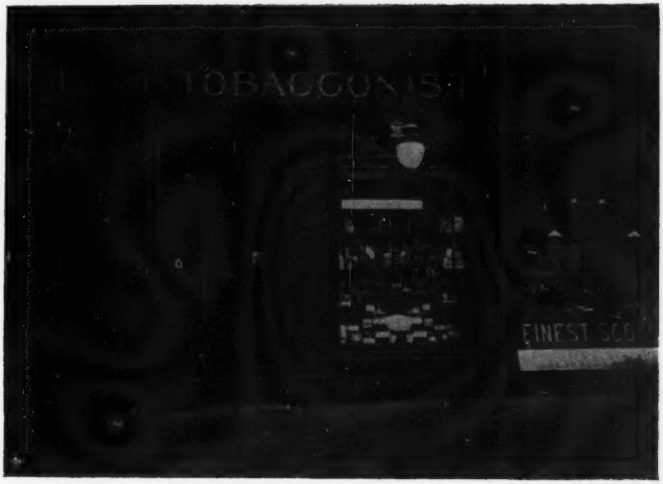


FIG. 5.—CORRESPONDING WITH FIG. 6.

lighting; interior, four 26-c.-p. Tantalum lamps at top of enclosure with 6-inch conical silvered glass reflectors; two 26-c.-p. Tantallums with N.P. shell reflectors below the centre line of the window; one 16-c.-p. ordinary lamp with N.P. shell reflector above spectacle case. Here the effect would have been better had the top row of lamps been concealed behind a window-blind or sale-bill, as in the following case.

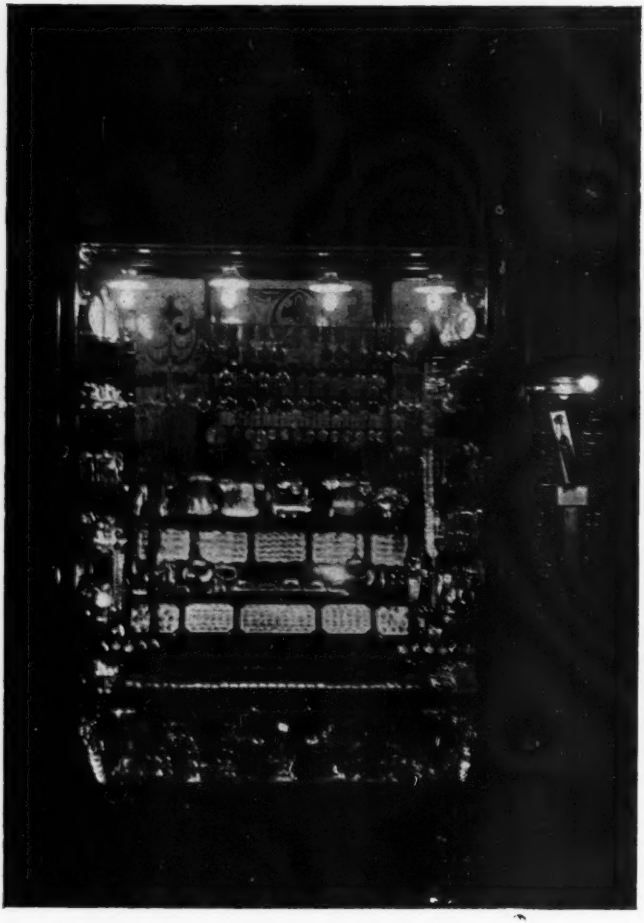


FIG. 4.—SHOWS THE SHOP PREVIOUSLY SHOWN IN FIG. 3, LIGHTED UP AT NIGHT.

(The exposure was, in the case of Fig. 4, 100 seconds, f.11. Imperial s.s. plates.)

Fig. 6 shows the tobacconist's shop having two 100-c.-p. Osram lamps —one in doorway, and one in outside lantern; four 30-c.-p. Osrams at top window behind the sale bill.

This photograph was obtained with an exposure of 1 minute, f.8., Imperial s.s. plates.

These are all well-lighted windows, and from the tables given below it will be seen that they come within the description economical.

In the table it will be noticed that two gas-lighted shops appear. These have been included for purposes of comparison. They are fitted with inverted incandescent gas-burners and are well-lighted windows. From the illuminometer readings a comparison can be obtained with the electrically lighted windows.

In calculating out the burning costs for the electrically lighted shops, no allowance has been made for the fact that the average price per unit taken over the whole year is less than $3\frac{1}{2}d.$ In the case of the first two shops, the average price per unit works out to about $3d.$, while in the case of the tobacconist, owing to the longer burning hours, the cost is only $2{\cdot}6d.$ per unit. In all these, however, the costs are reckoned on a basis of $3{\cdot}5d.$ per unit, which is the maximum

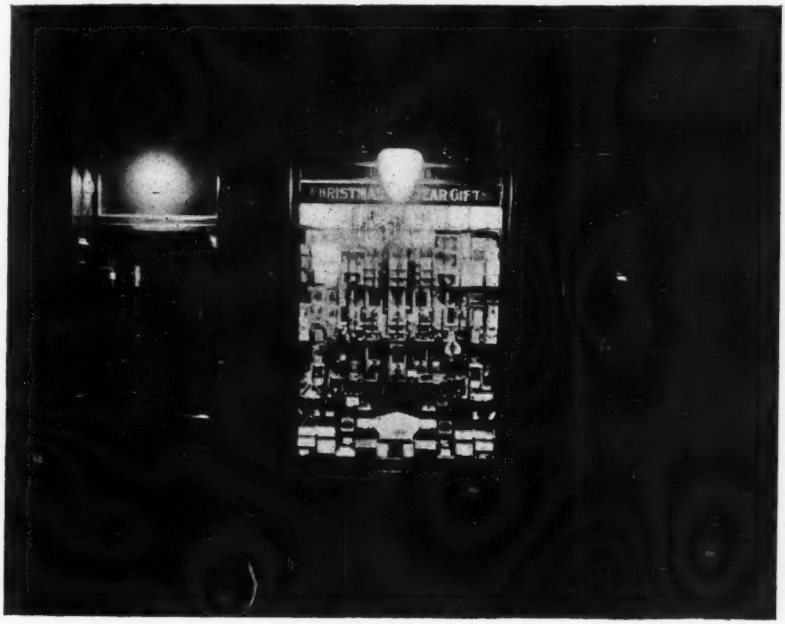


FIG. 6.—SHOWS SHOP PREVIOUSLY SHOWN IN FIG. 5, ILLUMINATED AT NIGHT. (Time, 9.30 P.M.)

NOTES ON TABLE I.

The "Illumination in candle-feet on a Vertical Plane" cannot be taken as anything more than a simple comparison; it is not a measure of the illumination on the horizontal plane, and is, indeed, only a small fraction of it; but as all the tests were taken under similar conditions, they can be looked on as accurately representing the comparative illumination.

charge. In the case of the gas-lighted shops the writer was unable to obtain accurate data as to the actual gas consumption of the inverted burner in use, and has taken $3{\cdot}5$ cubic feet per hour as the basis for his figures: he has reason to believe that this is quite fair to the gas interest.

In the column headed "Relative Costs for Equivalent Illumination" figures are given, using the most eco-

TABLE I.

TESTS MADE WITH EVERETT-EDGCUMBE PORTABLE PHOTOMETER, GLASGOW, 10TH JANUARY, 1908.

Description of Business.	Particulars of Illuminant.	Consumption.		Illumination on Vert. plane in candle feet.		Cost of Illuminant.		Burning cost per hour.	Relative Costs for Equivalent Illumination	Remarks.
		Watts	Cub. ft.	Close to Glass.	3 ft. out from Glass.	Per Kilo-Watt. Hour.	Per 1000 cubic feet.			
						Maximum demand System.		*d.*		
Hatter and Hosier A	2—3 amp. Enclosed Arc Lamps	990	—	·5710	—	3·5*d.* & 1*d.*	—	3·465	3·093	Tests A & A_1 with Arcs "on."
,, ,, A_1	4—30-c.-p. Osram ,,	990	—	—	·4000	,,	—	3·465		Tests B & B_1 with Arcs "off."
,, ,, B	2—26-c.-p. Tantalum ,,	240	—	·4242	—	,,	—	·840	1·000	Mostly dark goods which reflected no light outwards
,, ,, B_1	,, ,, ,,	240	—	—	·3043	,,	—	·840		
Jeweller	6—26-c.-p. ,, ,,	330	—	·3700	—	,,	—	1·155	1·275	Brilliant reflection from Silver goods.
,,	1—16-c.-p. Carbonfil ,,	330	—	—	·4240	,,	—	1·155		
Tobacconist A	4—30-c.-p. Osram ,,	300	—	·0581	—	,,	—	1·050	4·991	A & A with 100 c.p. Osrams "on."
,, A_1	2—100-c.-p. ,, ,,	300	—	—	·1071	,,	—	1·050		B & B_1 with 100 c.p. Osrams "off."
,, B	,, ,, ,,	160	—	·0416	—	,,	—	·560	4 783	Window with a fair proportion of dark non-reflecting goods
,, B_1	,, ,, ,,	160	—	—	·0600	,,	—	·560		
Stationery and Fancy Goods	6—"Falcon" Inverted	—	21	·0395	—	—	2*s.* 4*d.*	·588	6·539	Window largely occupied by dark photo frames, &c.
Stationery and Fancy Goods	Incandescent Gas	—	21	—	·0441	—	,,	·588		
Confectionery	5—"Falcon" Inverted	—	17·5	·1012	—	—	,,	·490	1·836	Window well mirrored and with light goods
,,	Incandescent Gas	—	17·5	—	·1304	—	,,	·490		

nomical installation as a basis of comparison. The writer would like to warn others against using this as an argument for one illuminant in preference to another. It is absolutely impossible to argue intelligently on the subject of illumination unless care is taken to compare things which are alike, and a glance at the last four shops given in the table will show some interesting results.

Taking the two gas-lighted ones first, it will be noticed that the stationer's window had a larger gas consumption than the confectioner's, and yet the illumination of the latter is found to be about three times the former.

The windows are identically the same size, and are quite adjacent to each other, and, as far as could be judged, there was no difference in the amount of light emitted by the burners in the two cases, consequently, the whole phenomenon hinges on the fact that the one window was filled with goods which reflected the light, while the other one had goods which only absorbed light.

Take again the jeweller's window and the latter (B) tests of the tobacconist's window, and a similar state is seen. Here, while the burning cost of the former is only three times that of the latter, the illumination is practically eight-fold. In this case also the shops are adjacent and the windows of the same size.

From considerations such as these it is quite apparent that the only absolutely correct way of comparing the relative costs of the various illuminants is to compare them in the same window and under identical conditions as regards window dressing. The writer hopes at a future date to inaugurate such a set of comparative tests.

Looking at the two which are in any way comparable, namely, the tobacconist (Test B) and the stationer, the goods in both of which were somewhat similar as regards reflecting properties, it will be seen that the relative costs are more in agreement than any of the others, the difference being in favour of the electric light. In this case it may be of interest to note that the electric light has been a proved saving in the annual bill.

The foregoing tests are only preliminary to a series which the writer is presently engaged on, and they are inconclusive in many ways. In future test readings will be taken to enable the illumination on a horizontal plane to be calculated, and an endeavour made to get an approximation to the reflection coefficient for each particular case.

(*To be continued.*)

The Standard Specification and the Consumer.

By an Engineering Correspondent.

On all sides one hears that we are on the eve of very great developments in electric lighting, due to the advent of the metallized filament lamp in different forms and in sufficient quantities to supply the demand. The future of the electric lighting industry depends to a very large extent upon the electric incandescent lamp.

It has often been pointed out that the determination of the most suitable lamp for the consumer depends to a large extent on the prevailing price of current, and not merely on the employment of the most efficient or cheapest lamp to be obtained in the market. Yet consumers on the whole are entirely ignorant of these facts, and are more or less at the mercy of the contractor.

It is surely time central station engineers employed means to assist their customers in the matter of the choice of their lamps. True, at present it is against clause 18 of the 1882 Act for the undertaker to prescribe any special form of lamp or burner, but this law is practically a dead letter, and, it is to be hoped, will ultimately be removed. The supply engineer will then be able to advise his customers to their mutual advantage, and we shall more nearly approach the ideal in which "light," and not "current" alone is sold to the consumer.

No doubt the establishment of a central station or of a few stations for testing electric lamps, controlled by a committee representing makers and supply engineers, with the assistance of the National Physical Laboratory, would greatly ameliorate the present unsatisfactory state of affairs, and be of untold benefit to the ordinary consumer, who could be advised to buy his lamps through the recognized channel.

Much time and money has been spent by the Engineering Standards Committee in drafting a standard specification for incandescent lamps; but if this specification is to achieve the success it merits, it must not be merely applicable to lamps purchased by the Government departments, but must also control those used by the public generally, and for this some such scheme must, without doubt, be instituted.

Lamp manufacturers would probably welcome such testing station or stations, for, with a standard specification to conform to and adequate supervision, ensuring the "standard" being of the same value throughout the country, it would not only aid them in their own manufacture, but would assist them in meeting foreign competition. Electric lamps can be made by our English makers every bit as good as by our American cousins, notwithstanding the isolated tests which have been published, and appear to prove to the contrary.

The high voltage continuous current circuits are much hampered in their efforts towards progress generally, not only from the fact that an incandescent lamp requires over 20 per cent. more energy for the same amount of light on a 200 volt circuit than on a 100 volt circuit, but also because the metal filament of the new lamps, even for those intended for 100 volts, is of so small a diameter, that it would appear likely to be some considerable time before a 200 volt metal filament lamp is a commercial success.

Thus for the present the low voltage direct current circuits and the alternating current systems, should reap the greatest benefit, and particularly the latter, which permits of a transforming device to reduce the P.D. to any desired value.

Artificial Illumination, and the Education of those concerned in its Production.

By C. W. Hastings.

(*Continued from p.* 57.)

Up to this time very little attempt had been made by gas engineers and managers to study illumination, and even at this epoch practical demonstrations were few and far between.

In 1879 a Select Committee of the House of Commons sat to consider the application of electricity for lighting purposes, the gas industry opposed, and ridiculed the movement—most unwisely as after events proved. The opposition was due mainly, we venture to think, to the want of scientific education; matters proceeded rapidly, and in the latter part of 1879 the first installation of electric lighting was inaugurated upon the Thames Embankment, under the direct auspices of the Metropolitan Board of Works, the then governing body of outer London, represented now by the London County Council and the many Borough Councils. The "City Fathers" were not behindhand in establishing electricity as an illuminant, and the Commissioners of Sewers, who were then the lighting authority for the City of London, installed electricity at Billingsgate Market. Both authorities adopted the Jablochkoff Candle, and although much was said and written about the excellence of the principle, the experiments were costly and short-lived.

We are not intending to trace the improvements made, but are going to endeavour to place in juxtaposition the knowledge that was brought to bear upon electric lighting and gas illumination.

The electric light, from its conception, was the idol of the public, courted by Royalties, Classes, and Masses—the first-born illuminant of the scientist, the chemist, and the mechanician; its production and brilliancy was a marvel to every one. On the other hand, gas and all that appertained thereto, had never been in favour; it was looked upon as an evil-smelling thing, of quite questionable use, and the public turned more and more against it; stocks and shares went down with a rush, but yet it is a fact that at no time during the thirty years under review has the sale of gas, taken as a whole, shown any diminution; from 1877 to the present time the output has greatly increased notwithstanding the millions of money invested in the production of electrical current for lighting and traction purposes.

The writer remembers two of the early demonstrations of electric lighting; the first was at the Albert Hall, when Sir W. H. Preece (then Mr. Preece) was responsible for the transformation of that magnificent building; H.R.H. the late Duke of Edinburgh, presided, and the company present included other members of the Royal Family, the nobility, the leaders of science, chemistry, art, and commerce. The scene was a complete revelation of the new light, and proved a wonderful send-off. The second occasion was even more wonderful, and dazzling in its beauty—the late Sir C. W. Siemens (then Dr. Siemens) was president of the Institution of Civil Engineers, and entertained the members, and a multitude of others, at the Inventions Exhibition at South Kensington; not only were the grounds brilliantly illuminated by electricity, but for the first time the visitors had an opportunity of witnessing the illumination of the fountains in many colours. Baskets of flowers were outlined by glow lamps, although they could not, at that time,

be purchased for less than five shillings each; the scene was superb, and will live in the writer's memory for all time.

Well, so much for the start; then came the Electric Lighting Bill of 1882, which, after many days in the Committee stage, became law. This Bill was feebly opposed by a few gas companies and corporations, who owned gas-works, and here as, we think, the great mistake was made—the gas interests should have worked hand in hand with the promoters of the Bill, and annexed the supply of electricity, on the old principle of uniting practice with theory. The gas industry had the organization, control of streets, knowledge of distribution, and their co-operation would have resulted in the saving of hundreds of thousands of pounds, and the ultimate cheapening of electricity per unit; instead, they opposed, shook their heads, and foolishly ridiculed the new light. True, for many years it was a luxury for the rich; but we have heard it said that illumination may be divided up into just the same number of classes as the ordinary railway train—first, electricity; second, gas; and third, oil lamps. Be that as it may, gas engineers and managers had to see their opponent making headway, and large consumers retained gas merely as a stand-by. Public lighting passed out of the hands of the gas companies; at whatever cost the public insisted upon having the new light, and efforts had to be made by the gas-makers to reduce the cost of production, to make the best of residuals, to increase the illuminating power of the gas they sold, and to make experiments with burners in order to secure a better illuminating duty per cubic foot of gas. After much trouble and very considerable expense, Whitehall was handed over to the Gas Light and Coke Company, so that they might show to what extent they could rival the electric light; the Company placed themselves in the hands of Mr. Wm. Sugg, and the important thoroughfare was brilliantly illuminated by means of clustered flat-flame burners, with the result that from the first experiment to the present time, Whitehall, from Charing Cross to Westminster, the Palace Yard, and the precincts of the Houses of Parliament, have been illuminated by gas. To-day the High-pressure gas system is in operation, and we venture to express the opinion that no thoroughfare in the kingdom is better or more cheaply illuminated.

What about the education of those responsible for the illumination of our streets and homes? We must admit that whilst electricity, from its conception, had the advantage of the most advanced scientists and cultured men in the land, very little effort had been made to educate the gas manager. Some few of the sons of the contractors' nominees had come along, and were holding positions, as assistant engineers, with their fathers, and were possibly better acquainted with the science and chemistry of gas-making; some, very few, had given the subject of photometry attention, but, in an industry that had no teachers, it was not likely that pupils should be forthcoming. The best of the men in the "seventies" and in the "eighties" had only received quite an ordinary education—served their time either as pupils to a consulting engineer, or been apprenticed to an engineering firm, who possibly might be engaged in the manufacture of gas-works' plant.

The proceedings of the Institution of Gas Engineers during the last thirty years prove that but few efforts were made to advance the education of the younger members of the profession. Presidents in their addresses have, from time to time, given some attention to the subject, more particularly in later years; but we think that the greatest incentive to the better education of the gas-maker was the movement made by the Corporation and Livery Companies of the City of London, who instituted an association in 1878, entitled the City and Guilds of London Institute, which had for its object the benefiting of those engaged in productive and technical industry. The Institute engaged in much admirable work, and was incorporated by Royal Charter in 1890. The work done in connexion with the Institute is very far reaching; students

may sit for examinations in most of the principal cities in the kingdom. There are some seventy or more subjects under the head of 'Technology,' and included in them will be found 'Gas Engineering' and 'Gas Supply.' Originally the course was confined to 'Gas Manufacture,' but in the last year or so the field of work has been extensively widened. Of our personal knowledge, we know many who owe their present position in gas engineering to the fact that they entered for these examinations, commencing in the Ordinary, and proceeding to the Honours grade.

We know of very many who have benefited by entering these examinations. There are now some twenty-four teachers in Technology, qualified for the section devoted to Gas Engineering and Supply. So far no effort has been made to educate the gas engineer in the science of Illumination, and we venture the statement that, although the Institution of Gas Engineers numbers 812 members of all classes, a very small percentage would be able to pass an examination upon the most rudimentary laws that govern Illumination.

(To be continued.)

The Lighting of Dark Spaces in Commercial Houses.

A RECENT article in *The American Gaslight Journal* brings out one important point in the illumination of business places.

The writer points out that in many warehouses and offices are dark corners which are never adequately illuminated, and which, therefore, fall into disuse. The writer's claim, in fact, is that space which is not illuminated is practically space wasted. Some gas and electrical engineers in America actually make a business of searching out dark places of this description, and persuading the houses concerned to adopt some satisfactory method of illumination. The saving of space which follows amply compensates the increased expenditure in lighting; and it is surprising how common ill-lighted basements and garrets which are devoted to the accumulation of dust and rubbish seem to be.

The author also comments upon the value of small portable lamps for the illumination of dark corners which are not very easy to get at, such as the illumination of the interior of pipes, sewers, and the like. For this purpose, electric portable lights, which can be easily thrust into the orifice in any position, without interfering with their functions, are at a distinct advantage.

Lighthouse Illumination.

By S. D. Chalmers, M.A.

Among the many problems which present themselves in lighthouse work we find two which are of special interest to the illuminating engineer :—

(1) The production of a source of light of sufficient candle-power and intrinsic brightness, and

(2) The design and construction of optical apparatus to utilize the light to the best advantage under the special conditions of each light.

The old-fashioned oil burner with its three or more wicks is still employed in many lighthouses, but in the modern and more important lights it has been replaced by an incandescent mantle burner, or in some cases an electric arc. In some few cases, where gas mains are convenient, the mantle is made incandescent by the use of ordinary lighting gas, but in most cases vapourized oil is used, and as this is capable of producing a more powerful light, it is sometimes preferred, even when lighting gas would be more convenient.

The burner in common use is similar to that known to illuminating engineers as the " Chance " or " Kitson " burner, or a modification of it, taking a Welsbach mantle 55 mm. diameter, and about 70 mm. high. In some special cases mantles as large as 85 mm. in diameter are employed. The candle-power of the standard size is about 1,300, with an intensity of about 50 c.-p.* per square cm. at the brightest parts. In practice different parts of the mantle show different intensities, and generally the *best* portion of the mantle is from 5 to 30 mm. above the burner. As in all incandescent mantles the candle-power falls off very rapidly at points above and below the horizontal, and this must be taken into account in estimating the value of the resultant beam.

Lighthouse burners are tested by direct comparison with a 10 c.-p. Harcourt Pentane standard. A Bunsen photometer is used, and a sufficiently long bar to allow the photometer to be used under normal conditions of illumination. No very great accuracy is obtained or claimed for these measurements. In actual use the mantle deteriorates considerably, even during its very short life. The oil consumption of the standard burner with a candle-power of 1300 is about 1¼ pints per hour.

It was at one time thought that the arc would be the ideal illuminant for lighthouse work, when the difficulties of keeping the arc and crater stationary were overcome ; but other and unexpected difficulties arose. It was found that the penetrating power of the arc lamp in fog was very much less than that of the oil or incandescent lamp, even when full advantage was taken of the possibility of increasing the size of carbons, and consequently the candle-power, for foggy weather. With the introduction of the " flame arc " this difficulty might be overcome, but there are difficulties connected with the optical apparatus which would hinder the use of even the " flame arc."

As is suggested above, the fog is one of the great difficulties of the lighthouse engineer. Perhaps the best illustration of its effects was furnished by the following experiment. On a very fine night a " landfall " light was visible on the extreme horizon when the lamp was replaced by an ordinary

* Some recent unpublished measurements by Mr. Walter Rosenhain give 50 to 60 c.-p. per sq. cm. for different mantles.



THE FASTNET LIGHT.

candle. In dull and misty weather the full candle-power of the lamp was required, and it was thought necessary to provide a duplicate apparatus with a similar burner to reinforce the beam in foggy weather.

Optical Apparatus.—There are two types of optical apparatus in ordinary use, the "fixed" and the "revolving." The "fixed" apparatus is designed to show a beam in all directions, or at least all seaward directions. When the angle to be covered does not exceed 180° it is possible to use a mirror to reinforce the light over the whole arc to be covered. The lenses and prisms of a fixed apparatus are designed to condense the light into a beam which has a small vertical divergence; but there is no horizontal condensation. In the "revolving" light the beam has a small divergence both vertically and horizontally, and the different directions are covered by rotating the apparatus, thus showing the beam for a limited time in each direction. In the slow revolving apparatus the period may be up to one minute with a flash of one to two seconds' duration; but in the best modern flashing lights the rotation is much faster, the period being generally 10 seconds and the flash $\frac{1}{15}$ to $\frac{2}{15}$ seconds. In many cases the light from the apparatus is divided into 2, 4, or 6 similar beams, each obtained from a similar "panel" of lenses and prisms. The object of this is to obtain a sufficiently short interval between the flashes without unduly diminishing the duration of each flash.

In some cases the beam is only required to cover a comparatively small angle, and the apparatus of a revolving light may be used in a fixed position, or a fixed light may be used and condensing prisms employed to direct the light, which would otherwise be wasted, into the desired direction. Similar condensing prisms are used to reinforce a coloured (red) beam when it is desired to indicate a danger zone through which ships must not pass.

In all lighthouse apparatus the source of light is placed at the focus of a lens or system of lenses, and thus the light from any one point on the source of light is made as parallel as possible; the light from the brightest part of the source is directed to the horizon, but, owing to the size of the source of light, the beam will have a divergence depending on the size of the source and the focal length of the lens. With a 55 mm. mantle, and a lens of 920 mm. focus (the first order light), the horizontal divergence will be $\frac{55}{920}$, *i.e.*, 1 in 17, or 3° 12′. The vertical divergence will be rather greater. It is sometimes, however, necessary to artificially increase this vertical divergence, by directing light from some parts of the apparatus to the near sea. The horizontal divergence represents about $\frac{1}{100}$ of the complete circle, *i.e.*, one flash would be $\frac{1}{100}$ of the time of a complete revolution.

It is not desirable to reduce the flash below one-tenth of a second, as otherwise the full intensity of the flash would, owing to physiological reasons, not be obtained, and many lighthouse engineers consider that flashes should not be separated by more than 5 seconds. This would require two flashes to each complete revolution, *i.e.*, a two-panel light. In the case of the landfall light on Fastnet Rock four panels are used; probably on account of the special prevalence of fog, which makes it desirable to have a greater proportion of light to dark intervals.

In some lights, groups of flashes are used to identify the light, two or more flashes occur in rapid succession, followed by an interval of darkness.

When less intense beams are desired, as for secondary or harbour lights, the size of the apparatus can be reduced and the beam made more divergent.

Since the intensity of the beam will depend on the quantity of light concentrated into it, as well as on its divergence, it is desirable to extend the lens system to intercept as much of the light as possible. Considerations of weight, absorption, &c., make it impossible to use one very large lens; Fig. 1 shows the vertical section of the lenses and prisms of a lighthouse system. The "fixed" system is obtained by rotating this section about the vertical axis through the focus (F);

the revolving system by rotating about the line (A F).

As each of the lenses A, B, C, &c., is made separately, it is customary to choose the curves so that all light from the focus is made as nearly parallel as possible. When the angle A F D is greater than 40° the losses by

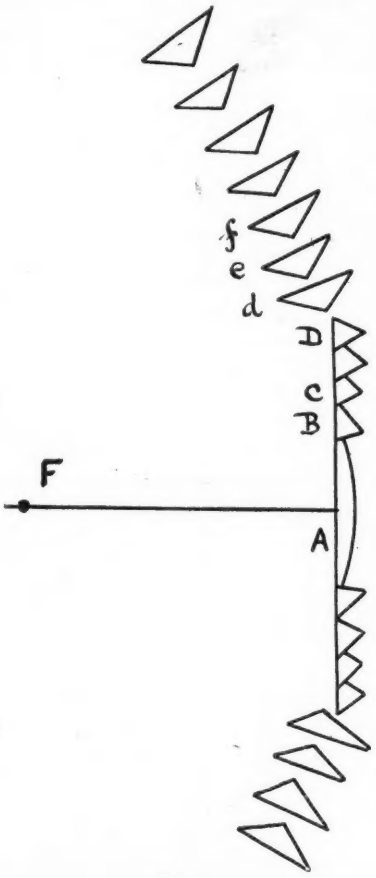


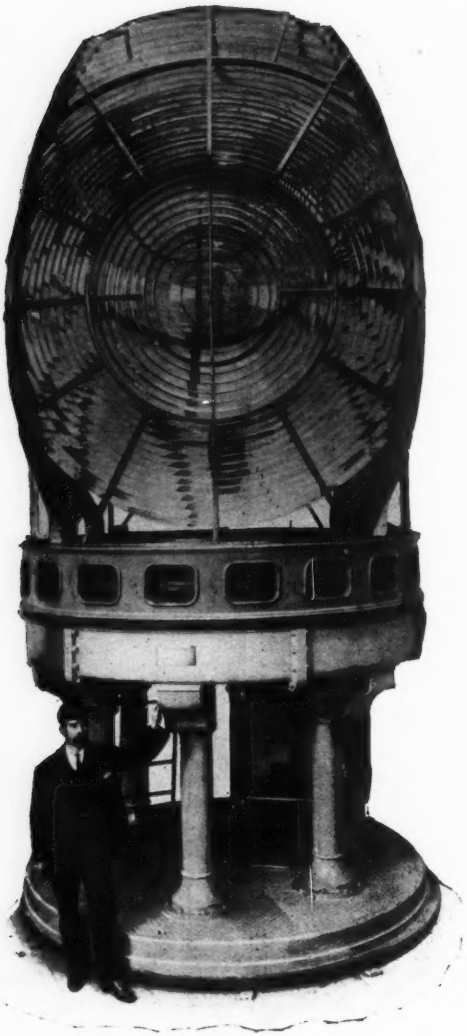
FIG. 1.

reflection from the surface of the lens are so great that it is preferable to use totally reflecting prisms *d*, *e*, *f*, &c. Such prisms may be continued up to an angle of about 88°, while at the sides they are limited only by the other panels or the framework. The lower prisms are fewer in number, partly owing to the cutting off of the light by the burner, but also on account of the service of the lamp. When mirrors are used they are generally constructed entirely of glass in the form of totally reflecting prisms, and are designed to concentrate the light nearly on the actual source.

The intensity of the beam obtained depends on the intrinsic brightness of the source and the area of the lens system. Were it possible to concentrate the whole of the light from the mantle into a uniform beam of divergence 1 in 17, this beam would represent a candle-power of $1,300 \times 4\pi \times 289 = 4,600,000$ c.-p. approximately; but it is impossible to utilize all the light in the direction opposite to that of the final beam, as the dioptric mirror only gives about one-third of the beam which would be obtained from the corresponding lens. Thus the full candle-power would be not more than 3,000,000. As a matter of practice light is wasted owing to the framework, and by reflection and absorption, while the candle-power of the mantle decreases rapidly as we depart from the horizontal plane.

In actual practice the beams from the various parts of the apparatus are of different divergences, and thus in the brightest part of the beam the candle-power will be rather higher than for the assumed uniform beam. It is more usual to calculate the beam as if the actual surface of the lens were of the same intrinsic brightness as the part of the mantle chosen for the focus of the lenses, adding one-third if there be a dioptric mirror reinforcing the beam. A normal first order light of one flash has a candle-power of about 2,000,000, while a double flash will give about two-thirds of this candle-power.

The actual candle-power is obtained by direct measurements. Each part of the apparatus is uncovered in turn and photometered, care being taken that the photometer receives the light which is emerging parallel to the axis of the apparatus. The sum of all these measured candle-powers gives the total candle-power of the beam in the direction of the axis; the total



CAPE RACE.

beam has also been directly measured at a sufficient distance to allow the photometer to receive light from all parts of the apparatus; but difficulties due to atmcspheric absorption, as well as the falling off of the various partial beams towards the edges, render such measurements untrustworthy.

The present directions of progress in lighthouse design consist in the use of much larger mantles (up to 85 mm. in diameter) with apparatus of increased focal length of 1,330 mm., giving about the same divergence as the present first order apparatus, and increasing the candle-power to one and a half of the value given above; bi-form lights, in which two similar systems, each with its own light, are mounted, either side by side, or one above the other, give twice the candle-power of the present lights. Burners are being continually improved, and the optical apparatus modified to secure better results.

The great outstanding difficulty is the production of a source of light which has great power of penetrating fog. Its intrinsic brightness and candle-power should not be much inferior to the mantles and burners at present in use, while absolute reliability in the hands of careful and skilled keepers is of the utmost importance, though it would receive every care and attention.

Some Notable Ocean Lights.

By A Correspondent.

A correspondent sends us some interesting particulars of some of the best-known lighthouses. Such lights are now usually run on the group-flashing system, originally introduced by Dr. Hopkinson, which serves to distinguish them from one another. This distinction is introduced by the variation in the nature of the flash itself, which may be single, double, or quadruple, and also by the interval between the flashes.

Three of the best-known lights constructed by Messrs. Chance of Birmingham are shown in the illustrations.

Cape Race is one of the largest ever produced, having an illuminator 85 millimetres in diameter. It is fitted with the incandescent vapour oil system, and has a hyper-radial single flashing apparatus of 1,330 mm. focal distance, consisting of four panels of 90 degrees horizontal angle. The light is also floated on mercury and operated by clockwork mechanism.

St. Catherine's has the distinction of being the second lighthouse to be equipped with electricity, and, like the Lizard, is one of the largest electrically illuminated lighthouses in the world. It is furnished with single flashing arrangements, the focal distance being 700 mm.; there are four panels of 90 degrees horizontal angle.

The Fastnet light is rendered peculiar by its dual form. It is supported on a single column, is described as a bi-form flashing apparatus of 920 mm. focal length, and consists of four panels in two tiers, having a vertical and horizontal angle of 90 degrees. The light has been in operation for four years.



St. Catharine's.

Church Lighting.

By An Engineering Correspondent.

It has always seemed to me that church lighting, judging from the standpoint of an electrician, must be placed in a category of its own. In almost every case where such work has to be carried out, problems of illumination are encountered which are met with in no other class of buildings. Theatres may be instanced as possessing peculiar features which throw obstacles in the way of satisfactory lighting, but it must be remembered that these difficulties are artificial. They exist because some unnatural effect is to be obtained, or some result entirely foreign to natural lighting is desired. With theatres the difficulty is not to light them effectively, but to light them to suit some particular stage effect, to produce some illusion of the senses, to work to the requirements of the artist rather than to the dictates of common sense.

With churches this is not, or at any rate very rarely is, the case. The difficulties which are to be met and overcome are the result of the building, and are solely due to its character. They are a part and parcel of its unusual shape, its extraordinary height, its arches, its huge shadow-casting pillars, its seating accommodation, its general arrangement. The man who has had no experience with such work, and who has hitherto only installed the electric light in shop windows and private houses, will find himself very much at sea when he first accepts a church lighting contract. Unless he approaches the problem in a scientific spirit and reasons the whole thing out at length, it is extremely improbable that he will turn out a satisfactory piece of work with a good lighting effect; it is much more likely that both he and every one else will be disgusted with he result, and that in the endeavour to improve matters he will put extra lights here, and lights of higher candle-power there, until he has produced a fairly satisfactory lighting effect, but at a ruinous price not only for installation, but for current consumption.

Nothing is ever lost by a few moments' thought and consideration. It may seem a waste of time to sit down and think out a job in every detail, instead of starting and getting it done; but in few things is this idea less true than in church lighting.

Everything has to be considered. The position where the supply authorities will enter the building should be ascertained first of all, and from that the whole arrangement must be built up mentally before a single light is fixed, or length of wiring run. The general scheme of lighting control must be gone into, bearing in mind the fact that at certain times very few lights will be required, and that it will be necessary to turn on a large number, or the whole, with very little trouble, and without the slightest confusion. The switching arrangement must therefore be so contrived that the switches are accessible to whoever it may be has charge of them at the moment when the extra lighting is required. There must be no scurrying across the church to get at the switchboard, no dislocation of the routine of the services.

Certain lights must be under the control of the organist, and these must be ascertained and planned out; others should be under the hands of the preacher, and these again must be placed where he will be at the moment when they are needed. Neither the organist nor the clergyman can with dignity rise and walk to a switch; it must be just where it can be used without disturbing in any way, either

physically or mentally, the audience or the officials.

Apart from the general arrangement and run of wires, the lighting itself requires considerable thought. It is to be remembered that it is most important that the lighting should be out of the direct line of sight of the audience. The effect aimed at is not brilliancy, nor a dazzling blaze, but a quiet, unobtrusive, subdued, and yet sufficient degree of illumination. The fittings are not designed to add to the appearance of the church, for it is always to be remembered that church architecture is of a type that gains nothing from such comparatively small affairs as electric light fittings and shades. The church effect is gained by bold sweeping curves, and springing columns; and the light should be contrived so as to bring out the beauties of wood and stone that otherwise are hidden from sight and knowledge; not so fixed as to attract the eye of the beholder. I have known architects who had control of church lighting, and who fixed the most vulgar of all vulgar *art nouveau* electroliers wherever, or so it seemed, the eyes of the audience could rest upon them. I have seen nice brassy garter-shaped fittings, with little brass bird-cage chains and nice yellow flexibles tastefully curled in and out, with sweet little rose-tinted shades hanging in the centre of grand old Transition arches in a fine old Transition church, where every stone spoke of the majesty of the past, and the abominable shrieking brassy vandalism of the electric light fittings simply told of the pitiful lack of taste of the present.

The fittings must be plain and unobtrusive, with the lights as far out of direct sight as possible consistent with proper effect and economy of burning. The old plan of lighting such buildings as we are discussing with immense electroliers containing fourteen- or eighteen-light fittings, in egg-shaped cut (or imitation cut) glass shades, must be considered to have had its day. It was the plan of the man who wanted to fix as few points as possible, and get as much for them as he could; and it was carried out by the man who, consciously or unconsciously, considered his work firstly from the standpoint of profit, and secondly from the point of view of speedy and easy working; the effect being quite a minor consideration. The church authorities were generally inwardly grumbling if outwardly uncomplaining. Grumbling not at the workman, be it noted, for he, it may have been felt, had done his best; the grumbling would be at the expensive nature of electric lighting compared with the results obtained. The electric light would be said to be trying to the eyes. The electric light would be too expensive. The electric light would be difficult to see by; and the electric light would be everything that was bad. And all for the want of thought on the part of some one or other in the first place!

With the old method mentioned the effect was that the light would be unavoidable except by those who were seated right in the front of the church. To those behind it would be impossible to look at the preacher except through a sort of halo of glass shades messed up with spidery fittings.

Such a method is therefore to be condemned. And but little if any better is the old-fashioned system of altering the existing gas fittings. It will almost always be found that these consist of upright brass standards, with seven or more branching arms carrying flat fish-tail burners. The gas-lighting was not particularly trying to the eyes, for two reasons. First, the standards were rarely arranged in the direct line of sight of more than a very few of the congregation, and, secondly, the light was never sufficiently powerful to do more than make the darkness visible. The method followed by many—usually because it is a simple and inexpensive plan—is to convert these standards. To that end, the branches are unscrewed and turned downwards with a half turn from the top bend, half-inch holders are fixed, and lamps inserted. The result is that the lights are some six or eight inches lower than previously, they are much more powerful, and they are conspicuous. The electric

light is once more condemned. Though it is admitted that the lighting is improved, yet it is considered trying for the eyes.

If this plan is followed, but the lights left upright instead of being turned down, the effect is perhaps not so trying, but the lighting is distinctly worse. The bulk of the light is thrown to the roofing, which is usually too far off to be reached, the principal portion of the light being, therefore, either lost, or else, in cases where the place of worship is fitted with a gallery, used to blind the eyes of the unfortunate worshippers sitting therein.

Speaking of galleries, it may be well to dispose of them as soon as possible by pointing out that these can be usually effectively illuminated by lights placed well back, so that the light is thrown from behind rather than from above or in front. Brackets on the stonework between the windows are usually adequate for this effect, but if insufficient, they can be supplemented by fittings of the Linolite type placed either on the pillars where convenient, or else hung down from the roof by light iron chains, the reflector being placed at such an angle as to prevent any of the people sitting behind seeing any of the actual lamps.

Another favourite method of church lighting is from the pillars, surrounding them with an array of lights, fixed on short wrought-iron arms pointing downwards at an angle of about forty-five degrees. In places this may be effective, but again the question of eyesight comes into consideration. In any case, the lamps should be frosted, unless the contractor is bold enough and strong enough to insist upon the use of a cup-shaped metal reflector shade that will entirely cover the lamp from sight, allowing only the space immediately beneath the lamp to be illuminated. In such a case the trouble is that the lights will have to be arranged with some degree of irregularity to get a good lighting result; but the use of such shades entirely prevents the bad effects mentioned.

The lights used must be powerful, unless they are in plain view, in which case they must be toned down as much as possible, and should consist of frosted lamps. But if the source of light can be concealed or totally screened from the eye, let the lights used be as powerful as possible. It is a fact that very excellent results have been obtained by the use of flame arcs; but without actually recommending these, it is evident that if they could be fixed so as to offend neither the visual nor the artistic senses, they would certainly be a most effective means of illumination; more particularly those of the pure white, daylight-effect type.

But without dealing with this point here, it is evident that the more powerful the lights, the fewer the points that will be needed, and for that reason it is evident that metallic filament, rather than carbon filament lamps should be used. The trouble in the way of this is that at the moment few of these lamps can be used other than in a vertical direction, and most fittings suitable for churches are designed for lamps to burn at an angle. But this difficulty can be surmounted with a little trouble and attention, if suitable reflectors are contrived for their use.

The ideal form of church lighting would be that in which the artificial illumination would be practically equal to that obtained during the average day; that would be free from alternations of glare and gloom, and that would be entirely hidden from the view of any one who had his or her attention fixed decorously upon the preacher or their books—the kind of lighting that would make a man observe to an acquaintance that such and such a church is beautifully lighted, and then be unable to explain how it was illuminated because he had not noticed.

It may be said that such a scheme might be admirable in theory, but well-nigh impracticable, on the ground of expense alone. I do not think this is so. The powerful nature of the lights would tend to cut down the number of points to some slight degree, and with lights fitted with metal shades and reflectors, placed in embrasures and niches, the expense of costly fittings would not be incurred. A considerable portion of the lighting

would be effected by what might be described as a kind of batten light, such as is used in theatres, and fed by a length of twin lead-covered cable. It is possible that all the risk and trouble of roof work would be saved, and it is certain that the effect of the work would be well worth the extra expense, if any.

With regard to the actual wiring, there is no method so suitable in every way as lead-covered work. Whether it be the lead-covered paper insulated system, or that in which vulcanized rubber wires are brought together and lead-covered, is practically immaterial. Personally I prefer the former, if only on account of the circular section, most of the small conductors of the other system being oval, and as such looking more like electric light leads; especially where bent out of the straight to turn at right angles.

These circular twin lead-covered wires can be run with ease practically anywhere in a church, and if the cable —which is comparatively inexpensive— is lavishly used, all points being brought back to the distributing centre, with no attempt at looping out or jointing unless such operations can be carried out without trouble, and in some hidden, or at any rate inconspicuous position, a very neat effect can be gained with a minimum of trouble.

Of course, a good deal depends on the structure of the building. As the lead-covered wire is to be unnoticeable, and we are insisting upon the fact that there must be nothing visible to offend the eye, either as regards fittings, lights, or wiring, and yet it may be necessary to run it along some stringer, or up the side of some pillar; it is obvious that it must be covered in some way by something that will harmonize with and blend into the building so as to be indistinguishable.

Stone and woodwork, fortunately for the artist-electrician, are the usual features of church work, so that he has not to consider a multitude of tones and shades. There are seldom any colour effects to be studied; and if there are, they are not insurmountable. The problem is how to run the wiring economically, taking all things into consideration, and yet to harmonize it with the building. For carrying out this four things only are necessary: common sense, paint, sand, and single-groove casing of similar wood to that used in the building. As the wire is wound off the drums it should be painted with a good quality paint of the same colour as the stone work; and as it is painted, fine sand or powdered bath brick should be sprinkled upon it and the whole left to dry. It will then, if run in straight lines, or curves to match the position, be practically invisible, especially after dust has toned down the newness of the work. Where it runs along the woodwork it should be covered with the casing, washed with water stain to match in tone. This is particularly easy with oak, which is the wood principally used in churches. Where other wood is used it is not quite so easy, and the wires must be run as much out of sight as possible. But with due consideration as to position of lights, on the general lines laid down in this article, and with sound common sense as to running of wires, it is not only possible, but comparatively easy, to realize the ideal lighting wherein the lighting effect is good, the lights practically invisible, and the wiring as inconspicuous as in the best class of concealed work.

SPECIAL SECTION.

The Illuminating Engineer as a Specialist.

THE "New Specialist," the Illuminating Engineer, and the proposed Illuminating Engineering Society have formed the subject of much recent discussion in the technical press.

In this section we are reproducing a number of the views which have been expressed on this subject, some of which date back to February, 1906, when the author drew attention to the subject in the course of a paper before the Society of Arts. It will be seen that the opinions expressed as to the value of the suggested "new profession" differ very considerably indeed.

On one point, however, there is now almost invariable agreement. It is generally recognized that many aspects of the subject of illumination are deserving of much more attention than they have hitherto received, and that a considerable saving could often be affected by an engineer who understood the requirements of good illumination.

Apart from the industrial aspects of the question, many people would also concede that the scientific side of illumination would benefit by some attempt to link together those interested, in order that a number of outstanding questions in photometry could be thoroughly thrashed out.

The only difficulty which some appear to find is the means by which these ends are to be accomplished. Our conviction of the value of the illuminating engineer and of an illuminating engineering society is evidently not shared by some of our contemporaries. We are sure that all possible objections to the proposed society, if fairly stated, can be met. We have therefore collected in these pages as many opinions, favourable and otherwise, as space will allow us to reprint.

THE ILLUMINATING ENGINEERING SOCIETY.

When the author in June, 1906, first drew attention to the value of such a society, the general interest in illumination was small in comparison with that existing at the present time. If any reader is in doubt on this statement, let him compare the number of articles dealing with illumination appearing in the technical press during the year previous to the date specified. Such articles were few and far between, and almost invariably referred to purely photometrical questions. At the present time the study of the current literature on the subject is almost too much for one man to accomplish. Some of us, however, even before that date had become convinced of the necessity of *some* system by which those interested in illumination could be brought together, and the author had conversations with the leading authorities on this subject.

The most natural suggestion was, of course, to endeavour to interest some existing society in the subject. It soon became evident, however, that no satisfactory solution could be reached

in this way, and for several weighty reasons.

In the first place, we felt that the ground to be covered in the subject was too wide to enable any existing society to be able to do justice to it. The second objection to the suggestion that illumination can be dealt with by existing societies, is the impossibility of bringing into contact the various interested parties under the present conditions.

For, naturally, the members of any society connected with an existing system of illumination cannot, however much they may desire it, take an impartial view of other systems, and would inevitably consider the subject only from their interested standpoint; consequently the electrical engineer would continue to be unacquainted with the systems of gas and oil lighting, &c., and vice versâ, or would treat the subject in a biassed manner.

Apart from the benefits which the engineers connected with different systems of illumination would derive from free intercourse with each other, they would also learn much by hearing the views of many, who though directly concerned with illumination, are not directly connected with the various engineering societies, such as, among others, the oculists, architects, and physiologists, whom an illuminating engineering society might succeed in bringing together.

These considerations led the author to next turn his attention to the possibility of bringing the various interested parties together on a joint commission. (It is interesting to note that one of our contemporaries, who had hitherto contended that the matter could be satisfactorily dealt with by existing institutions, has recently come into line with our ideas so far as to recommend co-operation between the gas and electrical societies.)

The author approached some of the leading authorities connected with the subject of illumination.

All agreed that some form of co-operation was desirable, but raised several difficulties, among the most serious of which was the question whence were the necessary funds and support for such a commission to be forthcoming, in order to carry on the necessary investigations, and what legal powers could be associated with their recommendations?

Moreover, it is common knowledge that even Commissions which receive Government support frequently lead to but small results after very protracted work, and that their recommendations, even when admittedly beneficial, often fail to be carried out in practice, or are postponed so long that their sphere of usefulness is much diminished.

In the case of illumination, too, much has yet to be learned before such a commission could issue definite recommendations, and it seems doubtful, therefore, whether the commission could lead to useful results before the subject was much further advanced. A society, however, by securing the necessary exchange of views, could collect data by watching the result of carrying their own recommendations into practice.

By this time the Illuminating Engineering Society had been started in the United States, and though its success was not then established, the author felt that such a society in this country would probably lead to useful results. He therefore addressed a letter on the subject to the editors of the great majority of the interested technical journals, as this, as will be seen, elicited many favourable opinions. From that date up to the present time he has also placed the matter before a great number of those most intimately connected with illumination in England, and while some doubted the feasibility of such a society, it was almost invariably conceded that it would do good work—if the various interested sections could be brought together.

Last year he also paid a visit to the United States in order to learn, by observations on the spot, the conditions which have contributed to the success of the American society. When the American society was first started, the illuminating engineer was regarded —to quote the expression of an electrical contemporary—"as a man likely to add to the gaiety of nations."

It was prophesied that it would be impossible to keep together in peace representatives of the different branches of lighting, that the subject of illumination would be quickly exhausted, and that the discussions of the society would quickly become weary, stale, and unprofitable.

But—to quote our contemporary once more—"the prophets have turned out to be windbags." The American society, which started with a membership of 89 members, has now, after an existence of only two years, a muster-roll of over 1,000, and five local sections, and the number of members and sections is continually increasing.

The papers read before this society are evidently regarded as of interest, for scarcely a week passes without one or other being reprinted in the chief American technical papers, while our own journals have not been slow to avail themselves of a similar privilege, and have frequently spoken in praise of their papers which they reproduced. This certainly does not convey the impression that the transactions of the American society had fallen to the low level foolishly predicted by some.

Nor does there seem to have been much of the anticipated friction between those representing the various branches of illumination to interfere with the working of the society.

As a result of many interviews with those representing the various interests, however, the author is confident that this difficulty will not prove to be serious in this country either, and that all sections will find it to their mutual benefit to hear what the other has to say.

It has been argued that the United States is more favourably situated in this respect than we are, because the gas and electrical concerns over there are frequently owned by the same people.

Yet there are a considerable number of cases in which gas and electric light undertakings are owned by the same authorities in this country. It is therefore of importance to the ratepayers to see that the lighting under these conditions is carried out in a scientific and satisfactory manner.

It seems to us evident that the existing institutions, though doing excellent work in their own spheres of activity, cannot attempt to deal adequately with such a wide subject as illumination.

For this reason there seems to us little ground for any fear that the Illuminating Engineering Society will prove inconvenient, in any way, to existing societies. In this connexion, however, we have a precedent in the result of the formation of the American society. When in the United States the author was personally assured by the secretaries of the various societies that the formation of the Illuminating Engineering Society, in spite of its rapid growth and comparatively great membership, had not proved inconvenient in any respect, but, on the contrary, had actually proved an assistance.

It is interesting to recall that exactly similar objections were raised against the formation of the Institution of Electrical Engineers. At that time many people professed to be unable to understand the necessity for more than one kind of engineer, and deplored the, in reality, perfectly natural tendency towards specialization; yet the value of the electrical engineer as a specialist is to-day fully recognized.

Now it is urged that the engineer has already more societies than he can attend to, and does not want another. It is, of course, becoming more and more difficult, even for a specialized engineer, to gain more than a very superficial knowledge of his special province. But to our mind, the increased specializing of societies is a perfectly natural movement, and, so far from being an inconvenience, is actually a facility to those interested in the special subject in question. One of the greatest inconveniences to which those interested in illumination have been exposed has been the fact that data bearing on this subject have been so extensively scattered. They have been obliged to scan the journals of many societies for the occasional papers and articles in which they were interested.

But the formation of a society

dealing with illumination alone would assist *everybody* to whom the subject must be indirectly of interest, for illumination is one of the necessities of life. Then, at any rate, every one would know where information on this particular subject was to be found when wanted.

Lastly, we wish to correct an impression that the proposed society is necessarily intended for the benefit of the declared "illuminating engineer" alone. It is quite clear that a society which depended for its support solely on the adherence of a type of expert who, at present, is—to say the least of it—rare in this country, would have a bad prospect before it.

It would, on the contrary, be of assistance to any one remotely interested in illumination, even if he proposes to restrict himself to one aspect of the question only. The success of the American society is in no small measure due to the wide variety of occupations followed by its members. An illuminating engineering society, in fact, commands the support of all who are interested in illumination, whatever be the special section with which they are associated. Only good can follow from a free exchange of the opinions of these different experts.

THE ILLUMINATING ENGINEER.

Let us now turn to the consideration of the "illuminating engineer."

From the outspoken opposition which has been excited in some quarters by the suggested creation of their expert, it might have been supposed that an army of illuminating engineers could be created in the course of a night, to swamp the overburdened engineering profession.

We only suggested that those connected with certain methods of lighting should themselves make a closer study of the various aspects of illumination in order to benefit the consumer and their particular branch.

We have never suggested that the expert impartial illuminating engineer must be developed from some class of engineer independent of any existing system of illumination. We see every reason to suppose that the necessary number of impartial experts will be recruited from those at first connected with electric gas or some other system of lighting, who, by gradually making themselves conversant with the merits and faults of the various illuminants from every point of view, will ultimately become illuminating engineers.

One of our contemporaries, in seemingly marked contradiction to views elsewhere expressed, goes as far as to declare :—

> "It would, of course, be an ideal thing to have an expert illuminating engineer without bias—an engineer capable of advising equally on the merits of gas, electricity, acetylene, oil, and other illuminants without any bias whatever,"

but fears that such an engineer cannot easily be produced.

Well, an ideal is worth striving for. It does not follow that because the present-day conditions are not, as yet, adapted to the needs of the illuminating engineer, they cannot be made so. We have not the least doubt that as the value of the illuminating engineer is more generally realized, any difficulties in his education will be overcome.

We believe that an expert of this description will ultimately be found to be a necessity, because illumination presents problems quite distinct from the system of lighting employed to produce it, and because the consumer would benefit by the existence of a specialist who would make an honest attempt to decide which of the various systems was most applicable to his needs on an impartial basis.

At the same time, we fully realize that such a qualified specialist can only be gradually evolved, and that his exact functions will be duly settled as his necessity becomes more evident.

THE NECESSITY FOR A JOURNAL DEVOTED TO ILLUMINATION.

While expressing our acknowledgment of the favourable comments on the appearance of our first number, we cannot refrain from referring to one criticism which was prematurely expressed before this number appeared.

We have been informed that "the subject of illuminating engineering is necessarily small" and that "the

creation of a technical journal devoted to the subject will only result in the artificial production of literature of a low standard."

It is a singular fact that all of the men who have really studied the subject of illumination—authorities like Sir Wm. Preece, Mr. Trotter, Prof. Blondel, Dr. Fleming, Dr. Bunte, Prof. Wedding, &c., to mention only a few names from the list of those who have promised their warm support to the movement—have been impressed with its vastness, and with the difficulty of keeping ahead of the ever-increasing development of the subject. It has sometimes been assumed that because those interested in illumination devote themselves to drawing attention to the more glaring and obvious defects, the subject will be exhausted when these points are dealt with.

We hear it said "Oh, we do not need an illuminating engineer to tell us *that*." "No one but a *lunatic* could think of doing so and so," &c.

Experts are agreed that these obvious and confessed defects in lighting exist on all sides. Naturally, therefore, our first duty is to draw attention to such examples of illumination as are obviously and unquestionably wrong. But in so doing we only touch the fringe of a very extensive and difficult subject.

We are satisfied that we can count on the co-operation of an extensive and distinguished collection of contributors. But, quite apart from the value of the original matter to be published, we believe that our systematic collection and reproduction of results published in this country, in America, and on the Continent will, in itself, render *The Illuminating Engineer* of great value to all those who are concerned with the study of proper and efficient illumination, and that the magazine will therefore satisfy a great want.

In what follows we give a résumé of comments which have appeared in the technical press during the last two years on the subject of illuminating engineering.

The space at our disposal only enables us to reproduce in abstract some of the views which appear to us of the greatest interest, and we have been obliged to omit those many instances in which the proposal of the Illuminating Engineering Society was referred to, without comment. In order to trace the gradual formation of public opinion on this point, we now give a brief history of the various articles, papers, and other publications which have been influential in turning it on the subject.

Interest may be said to have been first aroused on the question of illumination by an article by the author in *The Times* (October 25, 1905) on 'The Standardization of Electric Light.' The publication of this article was followed by prolonged correspondence from manufacturers of glow-lamps and others concerned.

The author subsequently read a paper before the Society of Arts (February 7, 1906) on 'The Progress of Electric Light,' in which the value of the illuminating engineer was referred to, and finally contributed an article to *The Electrical Magazine* (June, 1906), entitled 'The Need for the Illuminating Engineer.' This article was reprinted, and reprints and abstracts of it were sent to the section of the technical press, and those authorities likely to be interested in the subject. Much comment on the subject followed, and the author had opportunities of discussing the matter in the course of interviews with those representing the different branches of illumination.

In August, 1906, Sir William Preece read a paper before the British Association on 'Glow-Lamps and the Grading of Voltages,' and commented favourably on the illumination specialist therein. During this meeting of the Association the author had again the opportunity of hearing the views of many experts on the subject, almost all agreeing with him as to the desirability of putting illumination on a more scientific footing.

In August, 1907, the author again referred to the subject in a paper before the British Association at Leicester, on recent developments in electric lighting. Before reading the

paper, and immediately after, he undertook visits to the United States and to the Continent in order to hear the views of those who were likely to be able to speak with authority on the subject, and to obtain their co-operation, and he has received every encouragement from all.

Finally, the author raised the question once more in his recent paper on 'The Province of the Illuminating Engineer,' read before the Association of Engineers in Charge (December 11, 1907).

The various comments which have been called forth by these different papers are reproduced below, the journals concerned being arranged in alphabetical order, and the individual references by date.

It is interesting to observe how the opinions changed as soon as the matter became more understood, and the position clearer defined. Readers will be able to form their own opinion afterwards, and, we trust, will agree with us that the matter of properly studying the illuminating problems deserves every encouragement.

There is one other point to which attention may be drawn. In what has been said above, the Editor has found it necessary to refer to his own pioneering work on the subject of illumination, but he wishes to make it clear that this has been done merely in order to trace the march of events.

The movement has received so many adherents as to be now an established fact; its success in the future is secured by the great number of authorities on illumination in this country and on the Continent, who are giving their warm support, and can no longer be considered to be dependent upon the efforts of any one man.

Comments of the Technical Press on Illuminating Engineering.

THE BUILDERS' JOURNAL.

July 18th, 1906.

ELECTRICAL NOTES.

An Illuminating Engineering Society.

"We drew attention in these columns recently to the necessity of lighting matters being placed in the hands of trained men."

The writer then describes the suggested Illuminating Engineering Society, and quotes from the article in which the suggestion was made in order to bring out its value.

ELECTRICAL ENGINEER.

July 6th, 1906.

"ILLUMINATION AND PHOTOMETRY.—There was read before the Illuminating Engineering Society a paper on this subject, the author of which, Dr. Louis Bell, made some valuable observations from an engineering standpoint, based upon physiological data. This important subject is only just beginning to receive the attention which is due to it, and we cannot conceive any body of men better fitted for its discussion than those who make the problem of illumination the speciality of their work and study. These are days of specialization; we can only expect, therefore, that engineering specialists shall set up their distinctive institutions for the organization and promotion of their interests. However much some may deprecate the multiplication of technical societies, it must be borne in mind that the weakness arising from this can only be urged when the diverse societies are likely to weaken any existing societies which have for their object the general advancement of a particular industry, or when their activities are out of unison with those of other societies. But we do not believe that a society, with objects similar to the Illuminating Society, comes under either of the categories we have mentioned, but, on the contrary, we are of the opinion that such a society is decidedly opportune. It is for this reason that we would encourage the formation of an Illuminating Society in this country, which we believe is already afoot."

The article then proceeds to discuss the possible efficiency of illuminants, and concludes: "There is a wide field open for investigations in this direction, and any results which would teach us how to place luminous sources with the greatest effectiveness at a minimum of expense and maintenance costs would be invaluable."

ELECTRICAL INDUSTRIES AND INVESTMENTS.

June 20th, 1906.

Comments upon the suggestion that an Illuminating Engineering Society, involving the co-operation of gas, electric, and oil authorities, so as to give the best possible results from the artistic, illuminating, and economical points of view.

The author remarks that Mr. Gaster "is evidently of opinion that the millennium has actually arrived, but for our part we question whether the mutually abusive interests could possibly work in harmony."

He then proceeds to deprecate the suggestion that the existing number of scientific societies should be increased, but concludes: "On the other hand, it cannot be denied that the illuminating question, together with the type of lamps, shades, and reflectors used under specified conditions, is a most important one."

August 28th, 1907.

"Let there be light."

Presumably Mr. Leon Gaster has been following the proceedings of the American Illuminating Engineering Society with an interest bordering upon absorption. The Convention, which has recently been held in Boston, certainly demonstrates the progress which has been made in the art of correct illumination on the other side of the Atlantic, and the many interesting papers read before the meeting will, perhaps, spur Mr. Gaster to fresh pioneering efforts in this country. At the time of his inception the illuminating engineer was hailed as a man likely to add to the gaiety of nations. It was freely prophesied, owing to the conflicting interests of electricity, oil, and gas, that a meeting of an illuminating society would have more the aspect of a bear garden than a sedate scientific assembly. Even in these columns doubts have been expressed as to whether all these interests could possibly be made to work in harmony; but, as is often the case, the prophets have turned out to be windbags, and the illuminating engineer, at least in America, is an established fact. Nevertheless, it is obvious that such an individual must be a person of strong will and even temper. He may have to deal with gas or with electricity, oil or acetylene, and know how to make the best use of any or all of them; and all this in spite of the fact that his usual work will commonly run in a single line.

But even these qualifications do not constitute all that is required of the illuminating engineer. He must possess a sound grounding in physics and chemistry, and some knowledge of physiological optics. He must be well up in the science and art of photometry, but above all he must have a lively sense of the artistic. We are quite in agreement with the necessity of scientific lighting by scientific methods, but science—even illuminating science—must not come along and abolish all the things it pleases us to call beautiful, because they do not happen to conform with the scientific ideas of the illuminating engineer." For science is not always beautiful.... According to the *Electrical World*, it will be some years before any proper training for illuminating engineers will be available; but it is not likely that illuminating engineers will ever become a great independent profession any more than has sanitary engineering, but it will doubtless become a well recognized branch, in which there will be many an opportunity for admirable work. Certainly Mr. Gaster and his followers are faced with a task not to be passed over lightly.

October 23rd, 1907.

"The Contractor."

Day by day the question of scientific illumination becomes of greater importance. There can be no doubt that this point has not, in the past, received that careful attention which the subject deserves, but with the introduction of high efficiency lamps, installation engineers all over the country are rapidly coming to recognize illuminating engineering as a most important branch of installation work. We can only echo the remarks of our contemporary, *Electrocraft*, in this matter. Illuminating engineering, says this bright American publication, is a horribly neglected matter; and there is much profit and reputation for the contractor who has the sagacity to take hold of this practically unused and tremendously important branch of knowledge. Illuminating engineering is a high-sounding title, but there is no need to be scared at this rather formidable

name; it is not half as discouraging as it looks. And if its few professional votaries joyfully revel in energy curves, photometrics, luminosities, and pupillary diameters, there is no cause for worry, The intelligent contractor may feel perfectly assured that a fair working knowledge of the principles governing the effective arrangement of lighting units can be easily enough acquired, and that its possession will give him an immense advantage over his fellow contractors not so equipped.

December 18th, 1907.

Is an Illuminating Engineer a Necessity?

The writer of this article is not sure, and thinks that the art of correct illuminating should be understood by the station engineer or contractor, and that there is little need for a profession entirely devoted to illumination

"It is all very well to talk about physical constants, units of light—the lumen, the lux, and the candle-foot—but, above all, sight must not be lost of the physiological aspect of the situation."

"There is no doubt that many installations could be improved, and present special difficulties, but the knowledge required for such successful lighting is a matter of experience."

In order to illustrate this contention the writer quotes some recent utterances on the subject of illumination, referring to the illumination of factories and libraries, &c.

ELECTRICAL MAGAZINE.

April 24th, 1906.

In our "Lighting Section" this month will be found the first portion of an interesting article by Mr. L. Gaster, pointing to the immediate need, not only for qualified illuminating engineers, but also for an association to further the science of illumination. It cannot be doubted that the time is now ripe for a concentration of effort to this desirable end, and we speciallly direct the attention of our readers to Mr. Gaster's admirable appeal for support.

The chief reason why this movement should be fostered and carried to fruition is its tendency to focus the interests of electrical and gas engineers on a common object, namely, the provision of efficient illumination apart from commercial rivalry. To achieve this object would be worth the expenditure of tireless effort, and if it can be attained, the thanks of the industry as a whole will be due to those directly or indirectly responsible for the result.

A Society of Illuminating Engineers would admit the exponents of lighting by electricity, gas, and oil; in fact, an effort would be made to give men a knowledge of all three without prejudice to either, so that an "illuminating engineer" would be qualified to advise on the installation of one and all such lighting methods. If this idea can be brought home, it will form a class of experts whose advice can be sought without fear of prejudice in favour of this light or that. Obviously here is an opening for the young men in the profession, men who, on leaving college, find new fields for the exploitation of their energies, and who frequently accept uncongenial and unprofitable berths. In the last part of his article, to be published next month, Mr. Gaster makes a direct appeal for help, which, however, we will not anticipate, but commend the subject generally to the notice of our readers.

ELECTRICAL REVIEW.

September 6th, 1907.

After describing a series of experiments on different methods of lighting carried out by the New York Edison Co., the writer on the subject concludes:—

"These results and conclusions are very valuable, and will probably be used with good effect by English station engineers. But, in all humility, we should like to know where in England there is a station staff which hunts round with a luminometer in order to record results for the benefit of its competitors as well as its consumers, and moreover where, on this side of the water, there is an office belonging to an electrical lighting company scientifically enough illuminated to be the happy hunting ground of a man intent on writing a research thesis?"

September 27th, 1907.

Illuminating Engineering and Electrical Contracting.

"The keen competition between rival forms of illumination is developing a very critical and discriminating spirit among those who are responsible for installing electrical fittings and accessories. It was formerly considered sufficient if the electrolier or bracket was artistic, novel in design. and moderately cheap. The design of globe or shade was left entirely to the fancy of the artist,

and within a very wide range the questions as to the total or partial frosting the engraving or etching of patterns, &c., on the glass, did not very materially affect the sale of the shade. Quite recently, however, the illuminating engineer has spoken somewhat emphatically with regard to electric light fittings, and those who are in any way interested in the design and manufacture of shades, pendants, and brackets, may be advised to note very carefully what this new form of scientist has to say."

The article then proceeds to refer to the difficulty of reconciling the artistic and utilitarian aspects of illumination, and proceeds :—

"There is every reason to believe that the illuminating engineer has come to stay, and that he is going to show the necessity for certain modifications of electric lighting fixtures." . . . .

And :—

"There is no doubt that the science of illuminating engineering is going to open up a new field of commercial exploitation. Large manufactures are becoming standardized. Development in future will probably proceed on the successful study of the requirements of consumers in their multifarious needs. For this reason the manufacturers of electrical fittings and accessories will doubtless make it their business to keep a very close eye indeed upon the investigations of those who are studying light effects."

October 4th, 1907.

Light Production and Illumination.

Points out distinction between light and illumination.

"Our methods of producing light are appallingly inefficient. We have got to learn the physical side of the problem, and to select substances, the molecular condition of which is favourable to light-production.

"But what makes questions of illumination so perplexing, is the fact that the physiological side—the effect on the eye—has also to be considered. Probably particular light of particular frequencies is suitable for special purposes. For reading print, for instance, we may not desire the same quality of light as for general illumination. Again, the condition of the eye at very weak illuminations is very different to the normal state.

"This point of view is far away from that of the average man with the photometer, who makes simple tests of 16 c.-p. lamps. It shows us that it will probably be years before the amount of knowledge concerning illuminating engineering will be sufficient to render operations in this field at all commensurate with the development in other spheres of engineering activity."

October 25th.

"The great danger about the new science of illumination is that in the multitude of voices raised in the professional pronouncement, with the ulterior object of constituting for each prophet a pretty little private practice, will ultimately get the subject into disrepute. Already the temptation among practical men is to argue that they got on very well with lighting their houses and chapels before all this attention began to be devoted to the higher science of illumination, and they cannot, or will not, see why the old empirical rules should not be followed as before."

The Electrical Review then proceeds to give some simple rules of illumination, quoting from *The Engineering News*, as respects the amount of light required for reading, and the illumination of drawing-offices, &c., and continues, "with such simple rules for guidance the plain unvarnished type of electrical engineer can go a long way towards designing his illumination, so as to give good and scientific effects, and the higher flights of calculation and obfuscation may be, to a large degree, left to those who have a larger amount of spare time on their hands than the ordinary electrical contractor who is conducting a thriving business."

THE ELECTRICAL TIMES.

December 19th, 1907.

"Can illuminating be measured with sufficient accuracy and with sufficiently simple apparatus to make it a practical basis for money matters ?"

The writer of this article apparently thinks not, and is impressed by the difficulties of applying the system in practice, even if its merits be acknowledged. The subject is treated in a humorous manner, however, and the article can hardly be considered in the light of a serious attempt to discuss the merits of the question at issue.

THE ELECTRICAL WORLD OF NEW YORK.

June 16th, 1906.

Illuminating Engineering in Great Britain.

"Our British contemporary, *The Electrical Magazine*, in commenting on a series of articles in its columns, by Mr. L. Gaster, on 'The Need for the Illuminating Engineer,' expresses the hope that its readers will respond heartily to the appeal for aid in the formation of a British Illuminating Engineering Society. No time, it says, should be lost, as the present position of illumination demands co-ordinate interest and co-operative effort for its establishment on an authoritative basis in this country. 'America has led off well. Already it can boast a society and two independent journals devoted to the subject. The state of affairs here needs both of these, and just as soon as they can be fashioned from the materials at disposal. We want the gas and oil man as well, and hope they will stand by the movement, as their interests are likely to be safeguarded equally with those of other illuminants represented. We have now done with the talking. The sooner the practical business is got down to the quicker the end in view will be attained.'"

That in this country the formation of a society to foster the interests of illuminating engineering was entirely justified is shown by the rapidly growing membership of the present society, which is now little short of 600, and promises to reach 1,000 by the end of the year, by the high character of the contributions available for its *Transactions*, and by the lively interest in the meetings as manifested in the discussions. Our British friends should not delay getting into line with the latest branch of technical specialization.

ELECTRICIAN.

April 12th.

'*The Engineering of Illumination.*'

"There has been a good deal of talk recently about the illuminating engineer, the idea being that a new kind of engineer should be evolved, to see that out buildings and our streets are lighted to the best advantage. Whether such an engineer, with a good knowledge of all methods of illumination, and not merely of one particular branch, is likely to be evolved, or whether, if produced, he would combine the disadvantage of a diffused knowledge with an incomplete knowledge of any particular branch, may be a matter of opinion; but certainly there does not seem to be any marked call for specialization."

The article goes on to declare that the engineer already feels himself overburdened by the number of technical societies, to which he must devote himself, and would not welcome another. Nevertheless, the writer realizes the necessity for better methods of illumination, and expresses his views on the subject for another column.

August 30th, 1907.

The Illuminating Engineering Society.

"An organization bearing the above title has recently been formed in America, and its roll of membership includes considerably more than 1,000 names. So vigorous, indeed, has been its growth, that a first annual Convention was held at Boston during the last two days of July, and, according to our American contemporaries, this Convention proved a 'noteworthy success.' The President of this society is Dr. C. H. Sharp, an abstract of whose address will be found in another column....At present, commercial photometry is delightfully simple, and it is questionable whether anything tending to complicate it will be welcomed by practical men. Of course if a new society, devoted exclusively to the study of illumination, is formed, then it is only natural that a large number of fresh suggestions should be made. However, as we pointed out in a leading article some time ago, the entire matter might very well be dealt with by existing societies, and we trust that the day is far distant which will mark the birth of an English society having the same functions as that just called into existence in America."

December 20th, 1907.

The Illuminating Engineer.

"There is probably no subject whose principles are equally well understood and so frequently violated as the subject of illumination. This is due partly, no doubt, to ignorance, and often to carelessness; for there is no great difficulty in understanding the principles themselves, although elaboration has been introduced from time to time in the units and phraseology that are used.

"In order to remedy this state of things it has been suggested that a special type of engineer, namely, the illuminating engineer, should be evolved. The process of evolution has, indeed, started with vigour in America, and now it has extended to this country, largely due to

the efforts of Mr. Leon Gaster, who last week read a paper on the subject before the Association of Engineers in Charge ....It appears to us, however, that existing engineers—the consulting engineer, the station engineer, or whoever is concerned with such matters as part of his usual work—should take the trouble to inform themselves on these questions without producing a new class of engineer ....It would, of course, be an ideal thing to have an expert illuminating engineer without bias, as Mr. Gaster suggests he would be—an engineer capable of advising equally upon the merits of gas, electricity, acetylene, oil, and other illuminants without any bias whatever. As a matter of fact, however, no engineer can receive his training in several branches of engineering. The chance is that he will be trained either as an electrical engineer or as a gas engineer, and he will naturally be biassed along the lines on which he has been trained.

"On the other hand, there is room for a good deal of useful information to be collected, and partly on that account it is proposed to form a new society, to consist of engineers of all kinds who are interested in illumination.

"Undoubtedly," the article continues, "societies working along such special lines often do useful work." It is feared, however, the multiplication of such societies is undesirable, and therefore the writer advocates co-operative action between the Institutions of Gas and Electrical Engineers and the formation of a Joint Committee.

ELECTRICITY.

February 16th, 1906.

"To fill the gap which at present exists between the supply authority and consumer, neither of whom profess a knowledge of the principles of illumination, Mr. Gaster suggests the creation of a new profession, namely, that of properly trained illuminating engineers. The suggestion is distinctly good; there is ample need for a consultant who thoroughly understands the principles of illumination, and the best way of securing maximum lighting efficiency at a minimum cost of electrical energy. At present our installations are planned by rule-of-thumb methods; so many candle-power for so many square feet to be lighted, and in the majority of cases, regardless of the purpose for which the light is ultimately intended, whether for reading or sewing by, or merely to illuminate a staircase or cupboard. All the many purposes for which artificial light is required call for different treatment in the matter of distribution, reflection, and shading, if the best results are to be obtained. There is obviously a field here for the man who makes a special study of the subject and becomes, in effect, an 'illuminating engineer.'"

December 27th, 1907.

Illuminating Engineering.

"It has now come to be regarded as almost inevitable that the efforts of pioneers in nearly every sphere of activity should meet with a resistance, both active and passive (of vigorous opposition on the one hand, and of ridicule, perhaps, on the other), which, at a later date, seems altogether out of proportion. But if resistance to the progress of any new idea or undertaking does not necessarily connote the futility or weakness of that taken in hand, neither does that sympathy which the foresight and courage of pioneering spirits awaken within us, exempt us from turning the searchlight of investigation upon that which we are asked to accept. Many of us in this country are watching closely the attempt which is now being made to create a new specialist in the engineering profession under the style of 'illuminating engineer,' and to combine the interests of electricity, gas, oil, and acetylene lighting. Mr. Leon Gaster is foremost among those who are trying to bring about this desirable state of affairs, and one cannot but admire the energy he is throwing into the movement, even if one doubts its feasibility.....Mr. Gaster is quite impartial in his leanings as between gas and electricity. What the public want, he says, is best illumination for the money spent, and it is quite unconcerned whether this is produced by gas or electricity. I doubt, however, whether Mr. Gaster will get either gas or electric light engineers to agree to this, and while the inevitable rivalry between the two illuminants continues, I fail to see how a common ground can be found upon which to combine two opposing interests."

THE ENGINEERING TIMES.

June 14th, 1906.

Notes.

"Mr. Leon Gaster, of 32, Victoria Street, Westminster, writes to us suggesting that the formation of an Illuminating Engineering Society would do much to advance and disseminate the knowledge relating to the science and art of illumination. The merits and faults of

the different illuminants now used for public or other lighting purposes will have a better chance to be discussed on a more scientific basis, and the sphere of useful application be easier defined for each of them. There is no doubt that great economics can be derived from the judicious selection of the system of lighting adopted and the type of lamps, shades, reflectors, &c., used for different purposes.....Such a society as Mr. Gaster suggests is already in existence in the United States, and is doing useful service."

After briefly outlining the nature of the sugested Illuminating Engineering Society and the advantages to be derived from it, the article concludes :—

"There is no reason why one formed in the United Kingdom should not meet with a large amount of success. We are acquainted with several lighting experts connected with large manufacturing concerns who would welcome the innovation."

GAS WORLD.

August 24th, 1907.

The Study of Lights and of Lighting.

"We reproduce in another part of our present issue some extremely interesting and useful particulars relating to the rating and application of various descriptions of artificial light sources, gas and electric, from the *Proceedings* of the New York Section of the Illuminating Engineering Society. The salient feature of the work of this society is the regard which is paid to the science and practice of lighting ; which is a study that has not hitherto received in England anything like the systematic and sustained cultivation that its importance deserves. We have on record a number of able papers treating of the subject ; but they are quite occasional in their origin and purpose, and it is by no means easy for a gas engineer, who happens to be called upon to solve a problem of lighting, to lay his hand upon precisely the kind of guidance in the matter which he may desire. In this country, both gas engineers and electricians appear to have concerned themselves more with the production of luminosity than with its proper applications, with the result that examples of the misuse of shades and reflectors, or their neglect altogether, are distressingly evident to any one with an eye for such things who takes an evening walk through an otherwise well-lighted street. It is not too much to say that the production of a good light is only half the battle. An equally important half is the proper distribution and utilization of the lighting effect, and this part of the field of operation of the two great lighting industries remains in a sadly chaotic state. In America, both kinds of light are now usually in the same hands, which greatly favours the development of a sound body of practice in their use. Gas engineers and electricians work in a common interest in many, perhaps in the majority, of the largest cities of the United States ; and one result of this unity of purpose is, according to such witnesses as Mr. H. L. Doherty, that the public indulges in lighting on a scale that has no parallel in Europe. Be this as it may, it cannot be doubted that the Illuminating Engineering Society, which is manned equally by those who on this side never meet upon the same platform, is doing excellent work in laying the foundations of a science of artificial lighting, upon which a sound edifice of practice can be safely reared. It is not for us to copy their organization ; but we can, at least, learn from their labours."

November 2nd, 1907.

The Science of Artificial Illumination.

Quoting from *The Electrical Review* of October 25th, agrees that :—

"The scientific aspects of lighting are being so overdone, that plain men can hardly understand what the high science means." The rules of good lighting, *The Gas World* thinks, are few and simple :—

"We quite agree that the fundamental rules of good lighting are few, and not at all difficult to understand, and that there is certainly no need for the creation of another technical society in England to cultivate this department of a gas or electrical engineer's professional acquirements, which has already been advocated in some quarters."

December 14th, 1907.

"Whether there is enough in the science and practice of illumination by gas or electricity to support a distinct branch of engineering is a question on which professional opinion is, and we think, will remain divided....There is room for improvement in some departments of existing lighting systems. On the other hand, the success of the New York society appears to be largely due to the local circumstance of the gas and electricity supplies being in the same hands, which is not the case in England."

JOURNAL OF GAS LIGHTING.

February 20th, 1906.

"Our readers are aware that a society has lately been formed in New York for dealing with questions relating specially to illumination; and it may be remembered that in the 'Journal' for the 20th of March last we offered a few observations on the scheme. It was then recognized that the idea of working up the art of illumination was an excellent one, and one which it was suggested might profitably engage the attention of the Institution of Gas Engineers, with, of course, special reference to the use of gas. We pointed out that outdoor and interior lighting are both susceptible of improvement—the latter chiefly from the hygienic standpoint—and remarked that a great deal might be done by 'the enunciation of correct and economic principles in regard to the distribution of light.' We gave a list of the papers to come before the new society, and heartily wished it success. It will be seen, from a communication which appears elsewhere, that a movement is on foot for the formation in this country of a society corresponding to the one in request of which our remarks were made. ....Mr. Gaster....acknowledges that by looking after the lighting business gas engineers have made illumination by gas what it is; but, with us, he thinks there is still more to be done in this direction. He does not anticipate that any antagonistic feeling would be created between different illuminating engineers by the formation of the proposed society. On the contrary, he thinks that each would endeavour to bring apparently conflicting interests closer together, by the exchange of views on the relative merits of the various illuminants. He considers that a society such as the one proposed should receive the hearty support of the councils of the gas and electric professional organizations and of the newly formed British Science Guild. We are pleased to direct our readers' attention to Mr. Gaster's proposal, and shall be glad to know their views thereon."

July 21, 1906.

A Society of Illuminating Engineers.

"As many of our readers are doubtless aware, a Society of Illuminating Engineers was formed recently in New York, the object being to discuss questions and disseminate knowledge respecting artificial illumination. A proposal is on foot to form a similar institution in this country. The British Institution of Gas Engineers is an able and influential association; but it naturally devotes most of its energies to problems relating to the manufacture and distribution of coal-gas. It therefore resembles the Institution of Electrical Engineers in dealing solely with the utilization of one form of artificial illuminant. The Society of Illuminating Engineers (we do not yet know precisely the title it is proposed to adopt) will thus fill a perfectly distinct gap in the existing list of technical bodies, as it will study the employment of any kind of illuminating agent irrespective of its origin. The private householder and the ratepayer display much ignorance regarding, and suffer seriously in pocket from unfamilarity with, the best methods of developing useful and economical light; and perhaps it is almost as safe to say that large numbers of men well acquainted with the manufacture and distribution of 'coal' gas or electric current are almost as ignorant of the best way to develop light as their own customers. Evidence of these misconceptions is seen in many of the contributions which appear in the technical Press."

The writer then proceeds to point out difficulties in the way of measuring the illumination and comparing the merits of different illuminants, and the first two refer to the necessity for carefully considering the arrangement of the fittings in a room, of the location of switches, &c. "Hence if the new Society of Lighting Engineers assists the technical man in acquiring trustworthy data as to illuminating effect and the result of particular style of furnishing upon reflection, if it gives him figures as to the loss in candle-power brought about by badly designed globes and the like, and by dirty fittings, it will do much public service."

July 30, 1907.

Illuminating Engineering Society of New York.

Refers to the list of papers to be read before the first annual convention of the society at Boston.

"This list of papers should make a most attractive programme, covering a wide range of topics, and laying before the members the results of a large amount of original research."

December 17, 1907.

The New Specialist.

The article acknowledges the need for greater care in the present methods of illumination, but doubts whether the new expert will receive due recognition.

It will be difficult to find the man who can maintain the requisite impartial attitude, and it is questionable whether his ruling would be accepted by those connected with a special department of illumination.

THE OPTICIAN.

August 30, 1907.

The Illumination Specialist.

"The illumination engineer would seem to be a modern necessity, and that his advent will not be long delayed seems pretty certain. Mr. L. Gaster, who has an important article on 'Illumination' in a recent issue of *The Times*, tells us that it is surprising how little attention has been given until recently to the systematic application of the scientific principles of artificial illumination. In addition to the imperfect methods of converting electric energy, &c., into light, a large amount of the artificial light that is now produced is unnecessarily wasted. There are many cases where the loss may exceed half or even two-thirds, as Mr. Gaster points out, but even more important than the economical side of the subject is the disastrous effect on the eyes caused by the numerous faulty lighting arrangements.

"The Optician and Illumination.

"The different purposes for which artificial lighting is required call for special treatment, if the best results are to be obtained, and it is this authority's object to indicate how, to a certain extent, matters may be improved by devoting special attention to the problems dealing with illumination. The important rôle this new specialist—the 'illuminating engineer'—will have to play in the near future may perhaps be better understood, Mr. Gaster considers, when it is realized that the expenditure for lighting in this country is estimated to exceed 36,000,000*l.* per annum. To make a conservative estimate, about 10 per cent. could easily be saved by properly looking into this matter, so that 3,600,000*l.* could be turned to better advantage and more satisfactory illumination be obtained. And as Mr. Val. Mackinney asked in our columns some good time back, what is the optician doing to get his share of this new development?"

PLUMBER AND DECORATOR.

July 2nd, 1906.

Illuminating Engineering.

"It is curious to notice how, amid the mutations of time and circumstances, the ordinary terms and expressions of common language change their significance and acquire new meanings. Had we spoken of 'illumination' to one of our predecessors represented in the recent pageants at Glastonbury or Warwick, he would, of course, have understood us to mean the decoration of missals and other dainty devices of that artistic kind. But Mr. Leon Gaster, the Consulting Electrical Engineer, writing in *The Electrical Magazine*, brings us up to date by suggesting that we of the twentieth century should be as artistic in our way as were our forefathers in the days of 'illumination' proper. Gas and electrical engineers, he holds, should form a society for artistic adornment in their separate methods of contemporary illumination. In place of the feud that now exists between the advocates of the separate illuminants, he proposes an exchange of views and a community of interests. Such an object he considers to be fitly comprised among the methods of the newly formed British Science Guild. One is always glad to welcome fraternization of this kind; and Mr. Gaster is able to point to an American solution of the problem which shows his idea is not impracticable. The growing recognition of illuminating engineering as an art is, he urges, indicated by the establishment of illuminating engineering under an expert at the American General Electric Company's works. If in America, why not in England? Why not, indeed!

"Gas v. *Electricity.*

"Why versus? Is there any real reason for the importation of this objectionable forensic term into the apparently peaceful atmosphere of general illumination? The question was approached rather than stated at the annual general meeting of gas engineers. It was, as we used to say in our schoolboy days, 'understood but not expressed.' With regard to the competition of electricity with gas, says the President, it might be that some epoch-making discovery like the Welsbach mantle might revolutionize the supply of electricity as this has done in the case of gas. Then where would gas be? At present the prospects of gas were never so promising. And yet even the presidential mind could not shake itself quite clear from the obnoxious

'versus.' Why should there not be room for both? The age needs illuminating from every possible quarter and in every possible way. The remedy suggested by the President is a sound one —'Cheap Gas.' Given that, we might hope to substitute for the objectionable 'versus' our own happier combination, 'Gas and Electricity.'"

THE TIMES ENGINEERING SUPPLEMENT.

August 21st, 1907.

"While in this country the gas and electric lighting interests carry on their controversial warfare at long range, in America there has just been held the first annual Convention of the Illuminating Engineering Society, which already numbers over 1,000 members, and which discussed quite impartially such subjects as 'Standards of Light,' 'The Inverted Gas Light,' and 'Acetylene Lighting.' While it may appear a matter of speculation as to whether any annual convention of this society may become a peace conference or a battlefield, there is undoubtedly a case to be made out for the friendly discussion of the respective claims of various methods of exterior and interior illumination, and the competing interests will naturally join forces in raising the general standard of lighting so that the consumer will provide more revenue for whichever system succeeds in obtaining his custom. There would certainly be no reluctance on the part of electrical engineers here to come into similar close association with gas managers, and it is not to be doubted that both could learn much more about illumination than the present average knowledge on the subject."

October 2, 1907.

(Page 319, under "Electrical Notes," by an Engineering Correspondent.)

"An effort is being made to repeat in this country the extraordinary success which has attended the organization of a Society of Illuminating Engineers in America, to which reference was made recently in these columns. No better time could have been chosen for the formation of a similar British society, for we are undoubtedly on the eve of a very important advance in the art of illumination. Both in the electrical and gas industries, considerable improvements are being made in lamps, both as regards economical consumption and effective distribution of light.....It will be the work of the illuminating engineer to advise how the utmost benefit may be gained in the employment of the products of the gas and electrical engineer; that is to say, how the light may be most usefully diffused and how its effects on the eyesight or general health may be avoided. As *The Illuminating Engineer* of New York claims 'Artificial lighting is one of the greatest industries of the world.'"

December 18th, 1907.

In view of the previously favourable attitude taken up with regard to illuminating engineering by this paper, and the fact that several recent numbers had contained a full column on the subject of illumination, and a résumé on the proceedings of the Illuminating Engineering Society, at the first annual Convention at Boston, the following remarks come as a surprise. In discussing the paper before the Association of Engineers in Charge on 'The Province of the Illuminating Engineer,' the writer remarks that the illuminations of the present day are much more satisfactory than the paper would lead us to suppose, and quotes the lighting of Oxford Street, the House of Commons, and St. Paul's Cathedral as prominent instances of progress in this respect. The writer concludes:—

"We are inclined to allow that there is need for a society or institution more adequately to represent industrial physics —somewhat on the lines of the Society of Chemical Industry; but while the present machinery is active, and while illumination forms so large a subject of discussion and experiment among existing technical societies, it is difficult to comprehend why a society should be formed to produce the 'new professional' for illumination purposes."

[The examples cited certainly do not justify assertions so divergent from those held by experts in illumination; all such opinions require careful consideration. We ourselves have emphasized the fact that much progress in the art of illuminating has been made in recent years, but we are equally certain that very great further progress is possible, especially by concerted instead of individual effort, and, it is to say the least, gross exaggeration to say that illumination forms such a frequent subject of discussion at existing societies.]

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

The Incongruities of the Present International Nomenclature Referring to Illumination.

By Dr. B. Monasch.

(Abstracted from the *Journal für Gas,*) &c.

The attempts that have been made to find an international unit of light by the Parisian Congress of 1881 were carried on by the Congresses of 1882, 1884, and 1889, and also by the International Electrical Congress at Chicago in 1893, and a similar Congress at Geneva in 1896. The formation of the International Photometrical Commission in 1900 did not result in the discovery of the desired unit. The Hefner lamp in Germany, the candle in England, and the Carcel in France were not to be displaced. Therefore, an attempt was made in 1903 to ascertain the relations between the commonly expected units, and the results carried out in the prescribed laboratories in England, France, and Germany, were officially communicated by the Commission at Zürich in July, 1907.

The system of 1896 proposed the international adoption of the word "Lux," as a unit of intensity of illumination; this term had been previously proposed by Preece at the Congress of 1889. We find, however, that the word "Lux" is followed by the word "meterkerze" in brackets, which apparently was intended to convey that the terms were synonymous.

It is not often that a term has found its way into general use as rapidly as the word "Lux," and it occurs in almost all the works of consequence which have appeared in Germany and France since the year 1900.

The word is short and etymologically correct, and is especially adapted to be the name of a unit in that neither the unit of light nor the unit of length enter into it. A unit is preferably denoted by a pure name rather than an attempt of definition. We call the unit of force a dyne and not a gram-centimetre (second)^2 similar remarks apply to the word "Meterkerze." Moreover the word Meterkerze is applied to the unit of illumination on the basis of the old German "Vereinskerze" = 1·2 HK. Thus 1 Meterkerze became 1·2 Lux, and at the same time two expressions were in simultaneous use for one and the same quantity.

The confusion which has arisen between the Lux and the Meterkerze is illustrated by the case of the well-known figures of the oculist Cohn, who in 1885 gave the value of 10 Meterkerzen as the weakest illumination permissible from a physiological point of view, and 50 Meterkerzen for the illumination by which the eye, without any effort of accommodation, can see as well as by daylight. These results are expressed in terms of the old German "Vereinskerze." If one converts them into Lux they become 12 and 60 Lux respectively. Yet one never sees these figures quoted, but invariably 10 and 50 Lux or Meterkerzen. The fact that the unit of candle-power in Germany has been altered since 1897 is sometimes lost sight of, and now, when figures of the older authors are quoted, one is uncertain whether they are really expressed in Hefner-candles or merely quoted historically.

It is, therefore, time that the word Meterkerze was struck out of the list of photometrical terms and superseded by the word Lux.

The confusion becomes more confounded when we consider the differing phraseology of different nations. The following standards of life are in use:—

In Germany the Hefner Lamp.
In England the Pentane ,,
In France the Carcel ,,
In America electrical incandescent lamps, attested by the Bureau of Standards at Washington, are utilized.

The units of light corresponding with the Standards utilized in the different countries are as follows:—

In Germany the Hefner candle.

In England and the United States the candle.

In France the Carcel and the Bougie.

Moreover, the word Lux has not found common use in some countries, which have relied upon compound expressions containing both a variable unit of light and a unit of length, which is also variable. We have, for instance, both the "candle-foot" and the "candle-metre," and both these quantities are used at the present day according to the taste of the author. One can, indeed, find all the following terms in photometrical literature of the present day:—

1. Candle-foot (England and the United States).
2. Candle-metre (American Institute of Electrical Engineers).
3. Carcel-metre (France).
4. Bougie-metre (France).
5. Hefner-foot (United States).
6. Hefner-metre (United States).
7. Lux (Germany, France, and the United States).
8. Meterkerze (Germany, now to be replaced by Lux).

This collection of words corresponds to the growth of the conception of illumination among different nationalities, and it appears possible that when the subject has been more fully taken up elsewhere, the list may be considerably augmented. Just as the poet, in the richness of his vocabulary, speaks first of the sea, then of the "briny ocean," and finally of the "grave of sailors," so the English term candle-foot undergoes several variations, and we find that in the hands of competent authorities this term in the plural becomes both "candle-feet" and "foot-candles."

Clayton Sharp has explained that combined words like candle-foot are essentially incorrect, because they denote the product of two quantities. Now the quantity candle-foot does not mean one "candle multiplied by one foot," not even one candle divided by one foot, but one candle divided by one $(\text{foot})^2$.

Further confusion also occurs when the term candle-power is used, for at the present day there are great varieties of lamps in use, arc lamps with coaxial and inclined carbons, inverted incandescent gas lamps, glow lamps with filaments of various forms, &c., which all possess different characteristic polar curves of distribution of light, these variations being accentuated by the use of various globes or reflectors. Therefore the term mean spherical candle-power no longer tells us all we want to know about a source. Similarly the introduction of tubes of light such as the Mercury lamp and the Moore lamp renders those laws, which are only applicable to "point-sources," no longer strictly correct.

Illumination is an idea which naturally grows up in our minds from the appearance of the surrounding illuminated objects. We know that the intensity of illumination due to strong moonlight is about 0·1 to 0·16 Lux. In the same way we know that 12 Lux enables us to read with comfort and without fatigue, and that even 60 Lux can be used without the eye becoming tired; but when we find these illuminations expressed in terms of different units, when, for instance, 0·1 to 0·16 Lux becomes 0·015 to 0·03 candle-feet, we do not readily recognize them. Yet the physiological impression of intensity of illumination itself is something quite apart from the method by which it is expressed. What we want to do is to form a mental image of this intensity of illumination, and the physiological impression is the same, whether we deal in Lux, candle-feet, or candle-metres. The extreme variations that may occur is illustrated by the following table:—

Results expressed in ...	Factor for conversion into the desired Unit.					
	1 Lux.	2 Hefner-foot.	3 Candle-foot.	4 Candle-metre.	5 Carcel-metre.	6 Bougie-metre.
1. Lux (Hefner-meter) ...	1	0·0929	0·0848	0·9132	0·093	0·8849
2. Hefner-foot	10·76	1	0·9132	9·84	1·001	9·52
3. Candle-foot	11·78	1·095	1	1·076	1·097	10·43
4. Candle-metre	1·095	0·1016	0·0929	1	0·1018	0·969
5. Carcel-metre	10·75	0·9986	0·9115	9·817	1	9·513
6. Bougie-metre	1·13	0·105	0·0958	1·031	0·1051	1

Hyde has recently pointed out that 1 H.K. is not equal to 0·88 candle power but 0·893.

At the recent International Commission of Zürich, too, Paterson showed that the old British spermaceti candle becomes 5 per cent. less than it used to be, if we expressed our candle-power in terms of the 10 c.p. Pentane standard, and two distinct values for the British candle-power are liable to be introduced by this circumstance. The Hefner-candle expressed in terms of the 10 c.p. Pentane standard has been found to be equal to 0·195. In the same way the Bougie-Decimale is equal to 1·13 H.K.

All this shows how important it is, when denoting all physiological impressions by a number, to be careful of the units in which it is expressed.

Finally as a result of these considerations the author submits the following suggestion:—

(1) That the International Commission on Photometry should insist upon the value of intensity of illumination being expressed in the selected international unit, and that while the different countries are at liberty to use their own units of length and candle-power in their measurements and calculations, the results obtained should be converted into values expressed in terms of the international unit—the Lux—by multiplying by a suitable factor. The word Lux seems best adapted for adoption as an international term specifying intensity of illumination.

(2) That the various German societies interested should decide that the word "meterkerze," regarded according to the system of 1897 as synonymous with Lux, should be removed from the list in favour of the latter term.

Arc Light Carbons for the Production of Actinic Light.

By Dr. Ludwig Marquart. D.R.P. 176,419.

From the *Zeitschrift für Beleuchtungswesen.*

Researches have shown that the photochemical effect of light from the flame arc is strongly accentuated by the presence of certain metallic salts in the carbons. This photochemical effect is quite distinct from the luminous intensity of the source, and is a function of the atomic weight of the added metal. By the addition of small quantities of such salts the actinic power of the ordinary arc light can be materially increased.

The metallic combination recommended consists of a mixture of equal quantities by weight of yttrium nitrate and lead nitrate, the mixture being added to the carbon dust in the proportion of ½ per cent. only. The resulting carbons have excellent qualities for photographic work; the luminous efficiency is not exceptional, but it is said that their action on silver bromide is five times that of ordinary carbons.

The Problem of Colour Photometry.

By J. S. Dow.

(Abstracted from *The Electrical World.*)

Until recently our sources of light resembled each other very closely in colour, because our light was invariably derived from incandescent solid particles, which, however, resembled the theoretical "black body" more or less closely. Under these circumstances, the natural period of the atomic systems of which the incandescent body was composed were not given free play; we therefore obtained a confused jumble of vibrations and a continuous spectrum.

But lately the utilization of "selectively radiating" substances—that is, which exhibit a preference for radiation of a particular wave length not in accordance with the black body law—has entirely altered the aspect of colour problems. By the use of this principle we may hope to be able to control ultimately the spectrum of our illuminants much more completely than at present; we may even succeed in limiting the output of a source of light to radiation of a single frequency, and, therefore, the value of light of certain colours, for particular purposes, is of greater interest than in the past.

In the first place, it must certainly be definitely recognized that, quite apart from the technical difficulties of colour-photometry, no rigorous photometrical system, not even measurements upon the spot with illuminometers, can yield all the information about a source of light that the illuminating engineer will frequently desire to know.

A source of light may be called upon to achieve many different objects, some of them not really connected with the power of creating brightness, *i.e.*, the "illuminating power" of the source. One extreme instance is the chemical and photographic properties of a source of light, but there are many others less remotely connected with the brightness, and yet depending upon certain frequencies of vibration, which may be of but little use from the point of view of illumination.

It does not follow that a source of light which is intended to illuminate a dwelling-room is also a good one to read by, or for the revelation of fine detail. In the first case we chiefly desire to exhibit the æsthetic qualities of the room, and our source of light must therefore be such as to give to delicate shades of colour their true values. In the second case we are chiefly anxious that the fine detail we are illuminating shall appear as "sharp" and clear as possible, and this is not a matter of brightness only.

Yet other cases occur in which the *brightness* is the essential quality, quite apart from the true delineation of colour. In such cases our object should clearly be to produce the efficient yellow light in the spectrum only, and not to waste energy in producing the deep red and violet components which, for a given expenditure of energy, add but little to the total luminosity of the source.

These are only a few of the many existing cases, each of which demands special qualities from the light employed, and therefore special methods of measurement. Photometry, as usually understood, concerns itself with the measurement of the power of creating brightness, on the part of the light tested—certainly its most useful but not its only function. In order to measure the value of light for other purposes we can only devise additional tests, not, however, made upon a strictly photometrical basis.

Let us now turn to the consideration of some of the difficulties which beset photometry proper.

In accordance with what has been said already, it will be admitted that a photometrical method of testing any illuminant, ought, strictly speaking, to be carried out in such a manner as to compare the brightness of two illuminated surfaces. This is accomplished in photometers of the ordinary "equality of brightness" pattern, such as the Lummer-Brodhun, the Joly, and the grease-spot photometer.

Unfortunately, in the case of differently

coloured sources of light, the average observer finds it very difficult to decide when the two photometrical surfaces appear equally bright. The author, however, is inclined to think that there is no insuperable difficulty in making such a judgment, that proficiency is chiefly a matter of practice, and that the personal differences of different observers who are not actually colour-blind are not so great as is commonly supposed. Probably many supposed "personal" errors may be traced to the fact that the two observers did not utilize the same portion of the retina during their observations, or otherwise failed to secure exactly the same physiological conditions.

To facilitate such judgments many special systems of photometry have been proposed.

For the moment, however, let us admit the possibility of a practised observer being able to make a fairly accurate judgment of the equality of brightness of two differently coloured surfaces, and consider what this judgment really means.

Such a judgment must invariably be affected by the effect mentioned by Lauriol, and by Dr. Lummer, in his recent letter (*Electrical World*, Sept. 21, 1907), namely, the influence of the portion of the retina on which the image of the illuminated surfaces is received.

It has long been known by physiologists that the central portion of the retina, the "macula lutea" or "yellow spot" as it is termed, is less sensitive to the green end of the spectrum than the surrounding portion. Suppose, therefore, that the image of the surfaces in a photometer illuminated by two sources which differ in colour, is received upon the retina, and we adjust the position of the photometer until the two surfaces appear equally bright.

Now, if we observe these surfaces at a different distance away, or replace them by others of a different size—if, in short, we do anything that causes the image of them to cover a different region of the retina—the photometer may no longer appear in balance.

When dealing with more or less pure colours the effect may be very marked indeed. In a recent paper before the Physical Society of London (*Proc.* Phys. Soc., vol. xx., 1906) the author described some experiments involving the phqtometric comparison of two glow-lamps screened with red and green glass respectively. The Lummer-Brodhun, Joly, and grease-spot photometers, which had previously been found to give concordant results for lights of the same colour, gave utterly divergent results in this case, while the results obtained from each of the photometers depended upon the distance away of the eye from the photometrical surfaces.

The "yellow-spot" effect, as for shortness we may term it, is well known to those who have studied colour photometry, but its importance from a practical point of view is certainly not sufficiently realized. In the experiment referred to, in which fairly pure colours were used, differences of the order of over 100 per cent. could be easily produced. Even when an Argand gas burner and an incandescent mantle were compared under the same circumstances, differences of more than 5 per cent. were readily obtainable, while the writer has met with differences between 20 and 30 per cent. when comparing a mercury vapour lamp with a carbon-filament lamp.

We must remember, too, that quite apart from the discrepancies in the readings of the various photometers, the sources of light which they compare will certainly be used to illuminate surfaces subtending a much greater angle at the eye than the surfaces in the photometers normally do, and that such photometrical tests may therefore fail to represent the illuminating power of a source in practice.

It may be remarked, however, that these effects are much more noticeable when the illumination of the photometer screen is low. There is, as we shall see later, a reason for this. Meanwhile it may be pointed out that, according to the author's experience, the difficulties of colour photometry are reduced to a minimum by using a moderately high illumination of the photometer screen, of not less than about one candle-foot, and only become really urgent when the illumination is reduced below one candle-meter.

This question of the illumination of the photometer screen naturally leads us to the consideration of another allied colour effect—the Purkinje phenomenon —which has been aptly termed "the nightmare of colour photometry." For some reason the Purkinje effect is much better known than the yellow-spot effect. Yet, although both effects are now believed to have a common physiological basis, the Purkinje effect, in spite of its notoriety, seems to exert but little influence on photometry as ordinarily carried out.

By the Purkinje effect is meant that, with increasing stimulus, the luminous sensation produced by the red end of the spectrum increases more rapidly than in the case of the green end. The effect is

now understood to be merely part of a more general physiological change which occurs in the behaviour of the eye at low illuminations, and has been often illustrated by the following simple experiment :—

Suppose we place two similar pieces of green and red paper, and illuminate them with white light. The red will then in general appear the brighter of the two when the illumination is strong. But when the illumination is weakened, the red darkens more rapidly than the green, which soon appears unquestionably the brighter of the two. After this point the colours begin to fade, and eventually the green appears white and the red becomes jet black. If the illumination is weakened still further, the green, too, fades away into darkness. In order to show this experiment well, the coloured surfaces must subtend a great angle at the eye ; while if the angle is very small indeed, the colours fade away together and the Purkinje effect does not take place.

Modern physiological optics endeavours to explain these phenomena by the consideration of the functions assigned to minute light-perceiving organs scattered over the retina and known, from their appearance, as the " rods " and " cones " respectively. According to the modern theory of the action of these organs, which in its most complete form is attributed to the German physiologist von Kries, the perception of colour is associated with the *cones*. These organs are also believed to be most sensitive to yellow light, and, while inactive at very weak illuminations, continue to respond to increased stimulus, once they have started, long after the rods have ceased to do so.

The rods, on the other hand, are supposed to be unable to perceive colour. All light, therefore, seen by means of the rods appears white, but the organs are most powerfully affected by light which is blue-green in character. The rods are also believed to be sensitive to very weak light at which the cones do not act ; but with increasing stimulus they soon become, as it were, saturated, and fail to respond any further.

At ordinary illuminations our vision is mainly carried out through the cone organs, and we see colour. At very weak illuminations, on the other hand, only the rods are in action. We cannot distinguish colours properly, and all objects appear a " ghostly " grey. As the illumination is increased, the cones suddenly begin to act. The colours appear, and a struggle for predominance between the rods and the cones takes place. It is to this struggle that the Purkinje effect must be mainly attributed, though there are possibly other influences at work.

From a photometrical point of view, therefore, it is of interest to know at what order of illumination the struggle between the rods and cones has been decided in favour of cone vision. This question, however, is complicated by the peculiar distribution of the rods and cones over the retina. The extreme central portion of the retina contains practically only cones, and therefore if the image of the illuminated surfaces falls within this nearly rodless region, the Purkinje effect is absent, or at any rate very weak. If, however, the angle subtended at the eye by the illuminated surfaces is great, many rods are in play, and by reason of their numerical superiority, exert an influence comparable with, and even greater than that of the cones. The Purkinje effect is therefore accentuated.

In ordinary photometry the angle subtended at the eye by the illuminated surfaces is usually small, and therefore the Purkinje effect does not become really noticeable except at very low illuminations; indeed, in the case of the author, well below one lux—are reached. In practice, however, things are somewhat different. In street lighting, in particular, where the illumination is frequently very low, and where vast tracts of pavement and roadway have to be illuminated, the Purkinje effect cannot fail to be in evidence. Illuminometer measurements on the spot are therefore preferable to values calculated from the candle-power of sources as determined at ordinary illuminations, with which, indeed, they are frequently in disagreement.

The irregular distribution of the rods and cones over the retina also explains very satisfactorily the " yellow-spot " effect, since the variations in the relative brightness of two heterochromatic surfaces can be ascribed to the variation of the proportions of rods and cones on the portion of the retina on which they fall. Other explanations, however, have been suggested.

The physiological peculiarities of the eye which arise out of the behaviour attributed to the rods and cones seems to be the chief difficulty in the way of accurate heterochromatic photometry. There are many points in dispute about these organs which are only imperfectly understood, and there are also other little understood minor peculiarities of the eye which affect the photometric comparison of sources of light differing noticeably in colour.

We see, however, that there is no escape

from these physiological colour effects. Even if we could devise some method of photometrical measurement which was not affected by them, we should still have to face their existence in practice, and the divergencies between the results of photometric tests and practical results would be greater than ever. The most satisfactory plan would perhaps be to fix, arbitrarily, the angle subtended at the eye by the photometrical surfaces, and the order of illumination at which the tests are to be carried out. Tests made on this system would possibly fail to represent the illuminating value of a source in practice, and would therefore have to be applied with caution, but they would at least be consistent among themselves.

Finally, a word or two may be said with regard to the various methods which have been devised to facilitate colour photometry. Evidently no such method can get over the inherent difficulties of the subject, but only postpone them. Many of the methods are open to grave objection on other grounds.

One class of these methods involves the comparison of the integral brightness of the differently coloured sources by utilizing certain portions of the spectrum only, and ignoring the others. In the methods of Macé de Lépinay and Weber the two illuminated surfaces of the photometer were equalized, first when observed through a red and then through a green medium. The photometrical results of the comparison of the red and green components in the spectrum, so obtained, were then introduced into a formula for the comparison of the integral brightness of the two lights which, be it noted, depended on the observation of colour effects by the deviser of the method.

Crova proposed to estimate the relative brightness of two heterochromatic sources by observation of brightness in the yellow region of the spectrum only. Apart from the experimental difficulties in the way of applying this method practically, it has much to recommend it, for, unlike the previous one, it certainly utilizes the most valuable portion of the spectrum from the point of view of illumination.

But all such methods as those of Crova and Macé de Lépinay are open to one objection, which limits their application very seriously. They are obviously only strictly applicable to the comparison of sources yielding a continuous spectrum. In the case of such sources as the mercury lamp, which yields a spectrum composed of isolated bright groups of lines, they break down entirely.

A method which has often been proposed, and which Dr. Lummer in his recent letters seems to approve, is the comparison, not of the power of creating brightness, but the power of revealing detail of a source of light. It has been urged, with a certain amount of justice, that what we chiefly desire from a source of light is this very power of revealing detail. Yet this is not invariably the case, and as the writer has suggested at the commencement of this article, tests undertaken with the object of determining the capabilities in this particular direction, must be regarded as additional, and not as a substitute for photometry proper.

Moreover, while feeling some trepidation in questioning the dictum of such an authority as Dr. Lummer, the author must confess that his own experience does not lead him to suppose that the "sharpness" of detail illuminated by coloured light could ever be made the subject of a reliable method photometry. For, apart from the seemingly inevitable want of sensitiveness of such a method, this "sharpness" seems to depend very greatly on the accommodation of the eye, which is not acromatic. The writer has recently* described some instances of the effect of this want of achromatism. We are virtually very short-sighted for the violet end of the spectrum. Therefore, while violet light is usually somewhat better than white light for the illumination of detail which is viewed at very close range, it is extremely bad for the illumination of objects which are to be viewed from a distance. Red light, on the other hand, is usually best for the illumination of distant objects.

These effects are naturally affected by the optical peculiarities of the eyes of the observer, and are not equally evident to every one. Indeed, the author has even met with some cases of observers who declare themselves unable to see any difference between the sharpness of the red and blue, under the conditions described above, and whose eyes were presumably either exceptionally well achromatized or capable of an exceptional degree of accommodation. But this only emphasizes the difficulty of devising any system of photometrical measurement dependent upon acuteness of vision. In any case results obtained with a photometer in which near vision is utilized would certainly be found inapplicable to the appearance of illuminated detail viewed at a distance of a few meters. When we remember, too, that the addition

* American *Illuminating Engineer*, March, 1907.

of light of an undesirable frequency may, while increasing the *brightness* of illuminated detail, actually render it more difficult to distinguish, the desirability of keeping any such method distinct from ordinary photometry is obvious.

Finally, mention may be made of a type of instrument which has recently attracted some attention, namely the flicker photometer of Rood. From what has been said it will readily be understood that whether the flicker photometer is affected by the usual colour phenomena or not, it cannot be expected to give consistent results with photometers of the equality of brightness pattern, which differ among themselves so greatly when the comparison of sources of light which differ in colour is attempted. As a means of avoiding the natural difficulty of forming a judgment of equality of brightness in the case of lights of different colours, this type of instrument has certain advantages.

On the other hand, while the claim that this instrument is independent of all colour effects, such as the results of colour-blindness, for instance, certainly cannot be substantiated, there is good reason to believe that the influence of the peculiar behaviour of the rods and cones is less evident in instruments of the flicker class. Yet it is very doubtful whether this is to be regarded as an advantage, and whether the instrument is not open to objection on physiological grounds for this very reason. The author has made some experiments on this point, the results of which he hopes to publish shortly. A complete investigation into the theory of the flicker photometer, especially from the point of view of reconciling its behaviour with the theory of the rods and cones, is very much to be desired, and no doubt the research which Dr. Lummer is undertaking on this point will afford very valuable information.

Meanwhile, a more general acquaintance with the physiological peculiarities of the eye as regards the perception of colour is greatly needed. The requisite knowledge, which would enable the illuminating engineer to cope with the difficulties which are inseparable from the use of coloured light, is almost entirely confined to physiologists, and is rarely available in a form which is applicable to actual problems of illumination. Many of the chief experimental results of the past, too, are the work of only a few, and how far they are applicable to the normal eye, and how greatly the eyes of different individuals differ amongst themselves, has never been satisfactorily determined.

We have yet much to learn as to the possible uses of light from different portions of the spectrum, and we have yet to contrive satisfactory and universally recognized methods by which the value of these portions of the spectrum for special purposes can be measured.

Colour Values of Artificial Illuminants.

By G. H. Stickney.

Transactions of the Illuminating Engineering Society (American), May, 1907, p. 282.

Artificial lights differ from daylight more or less in their composition—that is, in the proportion of different colours they contain; for instance, a light may have too much red or the violet waves may not be present in sufficient quantity. On the other hand, certain artificial lights emit an excess of violet, and others are exceedingly rich in yellow or green.

In all cases where the so-called "daylight balance" is not maintained the light is no longer white, but the excess or absence of some particular colour is noticeable not only in the colour effect, but in a general lack of clearness.

It is generally known that the mercury arc does not contain any appreciable amount of red. A piece of material which would reflect red rays under a white light would appear black by total absorption under the mercury light.

Yellow materials displayed in the light of the Nernst or incandescent lamps become pronounced, and slight differences in pale yellow can hardly be distinguished from white, as the latter is capable of re-radiating almost as much yellow light as the former. The same relation exists between green and white exhibited under the Welsbach gas or vapour hydrocarbon lights.

Direct and alternating current enclosed arcs, particularly the latter, emit an excessive amount of violet light when equipped with clear globes, so that blue and violet materials exhibited under this light are stronger than they would be in average daylight. The violet light is emitted by the arc itself, while the white light, which forms 75 to 80 per cent. of the total luminous flux, is emitted directly by the crater.

Before the enclosed arc is suitable for accurate colour selection, the excess violet light must be disposed of. This can be accomplished by using opal enclosing globes, and still further improvement may be made by the use of suitable reflectors coated with enamel, having a high selective absorption for violet waves. We, therefore, have at our disposal means of purifying the arc light to a high degree, so that coloured goods can be displayed with practically daylight effect.

Instruments for Colour Comparison.

In order to bring out prominently the superiority of the arc lamp for colour-matching and selection, three instruments have been devised, namely, the "lumichromoscope," "photochromoscope," and "parachromoscope."

With any of these instruments a prospective buyer may compare the effects of various lights on coloured fabrics, and such apparatus should be of value

The Effect of Coloured Lights on Aniline Dyed Materials.

From Tests by M. Chevreul at the Goblin Tapestry Works.

With Additions by W. D'A. Ryan.

Orange	rays	falling	on	white	make	it	appear	orange.
"	"	"	"	red	"	"	"	reddish-orange.
"	"	"	"	orange	"	"	"	deeper orange.
"	"	"	"	yellow	"	"	"	orange-yellow.
"	"	"	"	green	"	"	"	dark yellow green.
"	"	"	"	blue	"	"	"	dark reddish-grey.
"	"	"	"	violet	"	"	"	dark purplish-grey.
"	"	"	"	black	"	"	"	brownish-black.
Red	"	"	"	white	"	"	"	red.
"	"	"	"	red	"	"	"	deeper-red.
"	"	"	"	orange	"	"	"	orange-red.
"	"	"	"	yellow	"	"	"	orange.
"	"	"	"	green	"	"	"	yellowish-grey.
"	"	"	"	blue	"	"	"	violet.

Red	rays	falling	on	violet	make	it	appear	purple.
„	„	„	„	black	„	„	„	rusty-black.
Yellow	„	„	„	white	„	„	„	yellow.
„	„	„	„	red	„	„	„	orange-brown.
„	„	„	„	orange	„	„	„	orange-yellow.
„	„	„	„	yellow	„	„	„	deeper-yellow.
„	„	„	„	green	„	„	„	yellowish-green.
„	„	„	„	blue	„	„	„	slaty-grey.
„	„	„	„	violet	„	„	„	purplish-grey.
„	„	„	„	black	„	„	„	olive-black.
Green	„	„	„	white	„	„	„	green.
„	„	„	„	red	„	„	„	yellowish-brown.
„	„	„	„	orange	„	„	„	greyish-leaf-green.
„	„	„	„	yellow	„	„	„	yellowish-green.
„	„	„	„	green	„	„	„	deeper-green.
„	„	„	„	blue	„	„	„	bluish-green.
„	„	„	„	violet	„	„	„	bluish-grey.
„	„	„	„	black	„	„	„	dark greenish-grey.
Blue	„	„	„	white	„	„	„	blue.
„	„	„	„	red	„	„	„	purple.
„	„	„	„	orange	„	„	„	plum-brown.
„	„	„	„	yellow	„	„	„	yellowish-grey.
„	„	„	„	green	„	„	„	bluish-green.
„	„	„	„	blue	„	„	„	deeper-blue.
„	„	„	„	violet	„	„	„	deep bluish-violet.
„	„	„	„	black	„	„	„	bluish-black.
Violet	„	„	„	white	„	„	„	violet.
„	„	„	„	red	„	„	„	purple.
„	„	„	„	orange	„	„	„	reddish-grey.
„	„	„	„	yellow	„	„	„	purplish-grey.
„	„	„	„	green	„	„	„	bluish-grey.
„	„	„	„	blue	„	„	„	bluish-violet.
„	„	„	„	violet	„	„	„	deeper-violet.
„	„	„	„	black	„	„	„	violet-black.

Predominating Colour of Artificial Lights.

Lamp.	Colour.
Enclosed arc—clear globes	Bluish white.
Enclosed arc—opal globe and selective diffuser	White.
3½ amp. 140 volt d.c. enc. arc.	Violet (beyond colour correction).
Nernst lamp—new glower	Pale lemon-yellow.
Nernst lamp—seasoned glower	Deep lemon-yellow.
Incandescent—new	Yellow.
Incandescent—seasoned	Pale orange-yellow.
Welsbach and vapour hydrocarbon—new	Greenish-white.
Welsbach and vapour hydrocarbon—seasoned	Greenish-yellow.
Ordinary gas flame	Reddish-yellow.
Mercury arc lamp	Blue-green.

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in convincing customers that a white light is indispensable for many classes of mercantile illumination.

The lumichromoscope is probably the most practical instrument for general demonstration purposes. This apparatus is arranged so that four lights, say of the arc, Welsbach, Nernst, and incandescent lamps, fall simultaneously on the material to be examined. Each light forms a patch 2½ inches square with a black border separating each square so as to reduce simultaneous contrast or gradation.

The lamps are arranged at such a distance that the relative intensity of the different lights falling on the material is the same, thus eliminating tint and shade effects, which take place when the intensities are of unequal strength.

The above tabulations give the effect of coloured lights on aniline dyed materials and the predominating colour of artificial lights in common use.

Intrinsic Brilliancy and Distribution.

It is generally admitted that the arc lamp is the most efficient source of artificial illumination, but, unfortunately, high efficiency generally goes hand in hand with high intrinsic brilliancy, and the distribution of the arc, in common with other artificial light sources, is not by any means ideal for general interior illumination.

This objection is partly met by the use of low power lamps, taking about 300 watts. These are especially useful in low studded rooms, or where there are many light intercepting objects in the area to be illuminated.

While the small units provide, possibly, a more uniform distribution, they are, unfortunately, associated with a considerable decrease in efficiency as compared with 500 to 700 watt lamps commonly used, to say nothing of the further disadvantage of a larger number of units to install and maintain.

With the elements of intrinsic brilliancy and distribution once properly disposed of, less weight will be given to the life of carbons, and greater attention will be paid to improving the efficieeny and stability of the arc by raising the current to the highest point consistent with a reasonable globe life.

There appears to be nothing on the horizon at the present time to rival the enclosed arc lamp for interior mercantile lighting, particularly where colour values are important.

While the tantalum and tungsten lamps represent a marked improvement in efficiency for lamps of the incandescent class, the colour has not been sufficiently changed to warrant classifying them as white lights. The magnetite and flaming arcs represent a class of efficient illuminants which, unfortunately, in the present forms, are not particularly adapted to general interior illumination, and therefore need not be considered in this instance.

The most promising immediate improvement in general lighting is through the use of high current enclosed arcs with proper diffusing devices.

DISCUSSION BEFORE THE NEW YORK SECTION.

(Slightly abbreviated.)

The Chairman (L. B. Marks).—I call the attention of those members who may not have seen it to an article in the April number of the *Century Magazine*, by Dr. E. A. Ayers, which gives a very able and interesting illustrated discussion of the subject of the address. It is well worth reading.

Among others we are favoured this evening with the presence of a distinguished representative of the English section of illuminating engineers, Mr. Leon Gaster.

Leon Gaster.—The question of the influence of colour upon sight is one which has received very little attention because the illuminants which vary much in colour have been very few, until quite recently. What the influence of the different coloured light sources, which have been recently introduced will be upon the sight, few have been able as yet to determine, as there has not been a great deal of information published upon the subject. It is believed that the defect of colour blindness transmits itself from generation to generation. Prof. Starling, at the Royal Institution of London, recently lectured on the question of 'Colour & Sight,' and showed the remarkable fact that colour blindness is mostly transmitted to the male descendants. If a man is colour blind and he has a son, the son will also be colour blind; but if he has a daughter, she will not be colour blind; yet if the daughter marries, her male descendants may be colour blind, although she may not be.

D. McFarlan Moore.—The three most important facts in connexion with any illuminant are efficiency, colour, and steadiness. A few years ago there was practically no way of changing the colours of the various forms of lamps—that is, the candle had its colour perforce: such a thing as modifying it was not dreamed of. The oil lamp had its colour; the open burner gas-flame its colour; the incandescent lamp its colour; and the arc lamp its colour. Then gradually attempts were made to increase the flexibility of our systems of illumination so far as colour was concerned, and, as we all know, the successful experiments in connexion with the Welsbach lamp form probably the most prominent example. At the present time there are only two ways widely in use of varying the colour: that is, if a person wishes to have a light of a different colour, there are two main ways of getting it. One way is to get another light source, and the other way

is to use a diffusion globe of some kind which, in any instance, is extremely unscientific and inefficient. Some of the most recent advances in this line are connected with the flaming arc lamp. There we have an instance where the first step, at least, was taken toward scientifically controlling the colour value. I refer to placing different chemicals in the carbon and thereby obtaining a colour which can, to a very great extent, be determined previously. But still it by no means can be said that by means of the flaming arc lamp the colour factor is under perfect control. However, it is possible now to have the colour value under perfect control, and this is obtained by utilizing a vacuum tube, and by changing the various gases used in the tube to change the colour. This has many advantages, and from a scientific standpoint it cannot be criticized as can the other methods which have been used. For example, if you use a properly regulated vacuum tube and feed it with air only, a pink light results; if you feed it with nitrogen a yellow light results, and such a light can be used for a great many purposes; in fact, its range of usefulness so far as the colour is concerned, is about the same as that of the ordinary incandescent lamp, and therefore can be used by florists or by clothing merchants, and the distortion is not any worse than that of the ordinary incandescent lamp. However, it is not by any means claimed that when a tube is fed nitrogen, that the colour is at all near daylight; it is simply a colour which appears about the same as that produced by the ordinary incandescent lamp. Due to the enormous radiating surfaces of the tube, the colour in daytime looks considerably redder than that of the incandescent lamp, because the lamp is extremely small as compared with the tube. When such a tube is fed with carbon dioxide at a definite pressure, and at a definite intensity, a light is obtained that undoubtedly is closer to average daylight colour values than any light which has ever been produced before, and we can almost say that it is entirely satisfactory. For instance, experts in matching colours in the largest dye works of this country, men who have tried all other forms of light and found them not at all suitable for their uses, have matched their colours under a vacuum tube supplied with carbon dioxide, and have found after months of practical use that they could not detect any difference between the most delicate lavender shades, when they are matched at night-time under the tube and in daytime by daylight, not direct sunlight.

Such a tube ought to be used as a standard of light. We are here to-night in an endeavour to reduce to an exact science the subject of artificial illumination, one branch of which has to do with colour values. The first step in reducing to a scientific basis any subject is to eliminate variables and decide on constants. This society should unite with other scientific societies, and decide on standard specifications for accurately reproducing the pure white light due to carbon dioxide in a vacuum tube. Then we could express other forms of light in terms of it. For example, if it was claimed that a certain light had a pink colour, it would mean that it was pink as compared with a standard carbon dioxide light. The next thought is that the standard of light, as regards colour values, ought to be the final form of light to use as the standard for photometric measurements, which are now influenced by the kind and quality of the light used as the standard.

The efficiency of any light source is largely dependent on its colour. This is due to the fact that the yellow rays have a maximum effect upon our eyes, and therefore a light which predominates in yellow or green has a better efficiency than one with a larger number of prominent colours.

Measurements of illumination are extremely complicated and will always remain complicated since they depend on the eye. The sphere of activity for illuminating engineers, as this matter of colour values becomes more and more refined, will become larger and larger. It is not a subject that will ever be reduced to simple mathematical terms. We can determine with great exactness the efficiency of a motor, but if we take the same amount of electrical energy and endeavour to determine the efficiency of the transformation when it is turned into useful illumination, immediately not only does the problem become complicated, but the objects illuminated also become of prime importance.

The history of colours of light as depicted by the various forms of light is extremely interesting, and the main point to be noticed is that as time has advanced the various forms of light have become whiter. The flaming torches of the Romans were extremely red. Then came the candle, the oil lamp, the gas flame, the incandescent lamp, and the arc lamp. We all remember how the arc lamp was considered a ghostly white light, and there was a great deal of objection

to it on that score. But artificial illumination has progressed, until we have come to the vacuum tube, which, when supplied with carbon dioxide, was criticized as being a bluish-white by those who did not realize that daylight is a bluish-white. Some of the best experts on illumination have declared, even in recent years, that a white light at night-time was unnatural. Such statements are dying out, and we will gradually hear less and less of them, until artificial daylight all night will be the universal demand.

G. L. HUNTER.—The efficiency of the different colours of lights in illumination varies greatly with the colour of the walls. When the incandescent bulb is used, a slight tint of orange on the walls renders the room more cheerful and brighter. A room with a light green paper is distinctly better lighted by the Welsbach lamp than a room with paper slightly orange. In practical illumination the colour of the light, as compared with the colour of the wall, must be taken into consideration; the colour of the wall is of the greatest importance. You may have all the efficiency in the light that is possible, but unless you carefully consider the various furnishings you do not get the effect that is desired. For instance, in a room where the upholsterings are of green and the walls of orange, the use of an orange light may actually reverse the contrast effects obtained with a green light. The orange light makes the furniture stand out, while the walls recede; with the green light the walls come toward you, and the furniture becomes less prominent.

DR. H. H. SEABROOK.—Mr. Stickney did not make entirely clear the question of the spectral colours in vision and pigment colours as applied to decoration. Most eyes see six primary colours; some of us are favoured by seeing seven. From the three fundamental pigment colours, red, green, and violet, all other colours may be formed by mixing. Colour blindness, absolute colour blindness, a pathological condition, cannot be helped. There is really no need of trying to educate people to see correctly who have real colour blindness. There is a lack of knowledge of colour affecting about five times as many men as women, and that is a condition which can be cured by education. With mixed colours, spectral colours and pigments follow a different law. The pigments, yellow and blue, will make green when mixed, because the yellow and blue neutralize, making grey, leaving the green to show; whereas in the spectrum yellow and blue, when mixed, are complementary colours, and form grey. Upon this the whole mathematical doctrine of the neutralization of colours by artificial light rests.

The question which Mr. Stickney brought out is not entirely that of matching colours in one special light; the point which might interest some more is the change of colours in different lights: how to know what the colour would be in daylight or some artificial light. Meyer in 1879 gave a colour analysis of the three light sources—kerosene, gas, and electric light; the constant was taken as 1 for yellow, expressing equal luminosity (these three lights are warm, with an excess of red); electric 2, kerosene 3, gas 4. For green these lights show respectively ·1, ·6, ·4; for blue ·8, ·2, ·2; for violet ·1, ·1, ·1. If you will remember that complementary colours are neutralized by an excess of a given colour in artificial light and corresponding colours intensified, you have what might be called the law of colours by artificial light. This law has been worked into exact mathematical formula by Dr. Franz Becker in an article entitled 'Untersuchungen über den Farbensinn bei künstlicher Beleuchtung,' to be found in No. 3 of Vol. LIX. of the *Archiv für Ophthalmologie*.

There is, however, a more important question than colour vision in choosing artificial light. In 1845 Brucke began the study of the effects of ultra-violet rays upon the eye, and injuries caused by these rays to the eye have been studied very thoroughly in certain quarters ever since by eminent experimenters. Briefly stated, all of them have shown that the anterior structures of the eyes are inflamed by ultra-violet rays, and that the human lens is injured by them, causing cataract, but that the lens absorbs these rays to a variable extent, thus protecting more or less the posterior structures of the eyes. As might have been expected, it has been shown that the blue and violet spectral light rays cause damage less in degree to the ultra-violet rays. Perhaps the most curious demonstration is that made by Dr. A. Birch-Hirschfeld. Eyes which retain the lens and the retina and are sensitive to ultra-violet rays are also sensitive to infra-red rays, but eyes without the lens are sensitive to ultra-violet rays only.

In 1887 Dr. Van Generen Short, in his experiments upon animals, found that the chemical rays of light which were not absorbed by the lens of the eye produced disassimilation of the retinal pigment. He found that the disassimilation and cell wandering was at a minimum in yellow light, which is, of course, the

light which contains the luminous rays in the greatest quantity. Following these experiments, Fieuzel suggested that protective glasses for the eyes should be of a grey yellow colour. Snow blindness and injuries from the electric light are both due to the chemical rays of light, including the ultra-violet rays. Snow blindness occurs only in the rarified atmosphere, because, as Tyndall showed long ago, the chemical light and ultra-violet rays are absorbed by the dust of the atmosphere. This gives a yellow tone to the light. Mr. Moore remarked that we do not have such a thing as constant daylight, and he picked out as a standard light, light on a cloudy day. Von Helmholz said that the best standard light was that found just inside a closed window, where the sun did not shine, on a bright day.

T. J. Little, Jr.—In the demonstration made by Mr. Stickney, unfortunately the best mantles were not used, but instead those giving what is known as a greenish-white light. In order for the Welsbach mantle to give a mellower light, the cerium content has been increased. We find that by so doing we increase the number of red rays and neutralize some of the green rays. I performed a very simple experiment in the laboratory recently by placing a bright red cone reflector above one of these green-white mantles, thereby increasing the red rays in the light thrown below the lamp, and differently coloured calicoes placed below the lamp immediately assumed their true tints, they having been first examined under daylight. The same material was then viewed beneath the light from a standard high grade Welsbach mantle, and the same result obtained as with the red reflector, showing that the green-white mantle could be improved in two ways: first, mechanically by the use of a red reflector, and second, chemically by increasing the cerium content. I believe the time is soon coming when all artificial light will be toned down to a soft colour.

G. H. Stickney.—From the general trend of the discussion I think, perhaps, that I have given the impression that I considered the arc lamp sort of a panacea for all lighting ills. I did not mean to do so. There are certain places where the enclosed arc light is unquestionably the most desirable illuminant available. In the lighting of large areas where good general illumination is desired, and especially where colour values are important, as in department stores, we have been able to obtain the best results by using the enclosed arc lamp, modifying the light distribution to suit conditions.

There are certain places, such as restaurants, residences, &c., where it does not seem desirable to illuminate with white light, yellow tinted light being preferable. In such cases, and where areas are small and ceilings low, it would be a mistake to install arc lamps.

On Luminous Efficiency and the Mechanical Equivalent of Light.

By Dr. C. V. Drysdale, D.Sc.

(From *Proceedings* Royal Society, A Vol. 80, 1907.)

In this paper the author describes some experiments carried out by Mr. A. C. Jolley and himself on the mechanical equivalent of light and luminous efficiency.

By "luminous efficiency," or, as Nicholls terms it, "total efficiency," is meant the percentage of the total energy of a source which appears in a visible form, *i.e.*, between the limits of 0·39 μ and 0·76 μ, in the spectrum.

"Radiant efficiency" is defined in a similar manner, except that in this case no account is taken of conduction and convection losses.

Luminous efficiency is a function of the wave-length of the light referred to, and, according to Dr. Guilleaume, is greatest in the case of light of wave-length 0·54 μ.

By the "mechanical equivalent of light"—as the author contends, a most important quantity from the point of view of light-production—we understand the power which must be radiated by a source of light in any direction in order that the intensity in that direction may be one candle-power.

The mechanical equivalent of light therefore enables us to estimate the actual energy needed to produce a given output of light, on the assumption that none is wasted in producing non-luminous radiation.

The author then proceeds to describe the actual apparatus and method of measurement employed, which involved the production of the spectrum of the source of light under investigation, and measurements of the luminosity and energy of the same.

Observations were carried out on approximately white light, and also on light on the yellow-green portion of the spectrum, where the greatest luminous efficiency was found by Dr. Guilleaume to occur.

The results of the author and those of some previous observers are grouped together in the following table :—

Mechanical Equivalent of Light.—Collected Values.

Observer.	Date.	Method	Source.	Unit.	Mechanical equivalent.			
					Calories per second.		Watts.	
					Per Hefner.	Per C.P.	Per Hefner.	Per C.P.
J. Thomsen...	1863	A.	Sperm candle	Sperm candle, 8·2 grammes per hour	0·065	0·0733	0 276	0 3075
	,,	,,	Moderator lamp...		0·0585	0 065	0·245	0·272
	,,	,,			0 0615	0·0683	0 257	0·286
	,,	,,	Gas flame..... ...		0·063	0·070	0·264	0·293
	,,	,,			0·0553	0 0615	0 232	0·258
O. Tumlirz and Krug	1888	A.	Incandescent platinum wire	Hefner	0·041	0·0455	0·1715	0·19
O. Tumlirz...	1889	A.	Hefner lamp.....	Hefner	0·0455	0 0505	0·191	0·212
K. Ångström	1903	C.	Hefner lamp.....	Hefner	0·0259	0·0288	0·1085	0·121
Writer and A.C. Jolley	1907	C.	Nernst filament ...	Candle	0·0256	0 0284	0·107	0·119
	,,	,,	Arc	,, ...	0·0173	0·0192	0·0725	0·0805
	,,	,,	Monochromatic, yellow-green.. ...	,, ...	0·01285	0 0143	0 0538	0·0598

Method A.—Thermopile and absorptive screens.
Method C.—Direct measurement of energy in spectrum.
In this table the Hefner has been taken as 0·90 C.P. See Paterson, 'Proc. Inst. E. E.,' vol. xxxviii. p. 586 and Fleming, p. 311.

Some Notes on Arc Lighting.

By William Krause.

(Paper read before the Junior Institution of Engineers, Dec. 10, 1907.)

The author specifies the year 1896 as marking the beginnings of progress in the arc lamp. The state of arc-lighting in that year is illustrated by a list in *The Electrical Review*, showing that of 123 stations in the United Kingdom, 73 reported a number of 2,260 arcs in use. The author, however, states that the total number probably approached nearer 3,000.

Although many "multiple-carbon" types of lamp have been designed, the industrial development of this idea has not been carried beyond the twin-carbon lamp. The longest burning on a single trim of a twin or double-carbon lamp using 12 amperes, and using 20 and 30 mm. carbons 12 inches long, is about 32 to 34 hours. By reducing the current to 10 amperes this can be increased to 40 hours, but, of course, only by a corresponding reduction in the light.

The development of the open arc is illustrated by the recent increase in the number of such lamps in use for public lighting. By the year 1903 291 out of 322 stations used lamps of this description, aggregating a total of 17,209, of which London alone contributed 5,138. By 1907 this number had reached 23,134, but, the author adds, the last two years have seen a diminution, the maximum being reached in 1906. The numbers quoted, he also points out, are not exact in that a few enclosed arcs were included among them.

The enclosed arc was also in use in 1896, but its advantage of long burning was very seriously discounted by the unpleasant violet colour of the light yielded by the lamp. Eventually, however, a compromise was effected by admitting more air to the arc. This resulted in a whiter light, but somewhat reduced the burning-hours. Another important improvement consisted in the doing away of the outer opalescent globe with the inevitable loss of light occasioned thereby, and making the inner globe also the diffusing one.

The idea of employing a volatile metallic salt in the core of the carbon in an arc lamp dates back as early as 1896, though the methods then proposed did not lead to any very marked result owing to several important essentials in flame-carbon manufacture being overlooked.

In such carbons it is of vital importance that the arc should remain centred in the core.

The rate of combustion of carbons is greatly influenced by the "economizer," or half-open chamber within which combustion takes place. In order to secure steady burning it is necessary to make the carbons of small diameter, with the result that both the rapidity of consumption and resistance of the carbons is increased. It has therefore been found necessary either to coat the carbons with metal or to introduce a metallic wire into the carbon; the latter appears to have given the best results. Another difficulty which the flame arc has to contend with is the deposition of a fluffy metallic oxides on the interior of the globe, &c., and as these fumes cannot well be avoided altogether, attempts are now being made to render the apparatus self-cleaning.

The author quotes the following figures of Prof. Elihu Thompson for the inefficiencies of the various types of arc lamp:—

	Watts per C.P.
Open type	0·70
Alternating open type with reflector	0·80
Single enclosed arc	1·50
Alternating open type without reflector	1·12
Enclosed alternating	2·0
Flame	0·15 to 0·30

One feature of arc-lighting in the streets on which the author comments is the tendency of the public to judge the illuminating efficiency of a source by the intrinsic brightness of the source itself. Thus while the introduction of intense arcs enables us to place them high up out of the line of vision, the man in the street is apt to think he is not getting his money's worth. In one instance lamps were actually lowered in deference to public opinion so as to produce the desired effect.

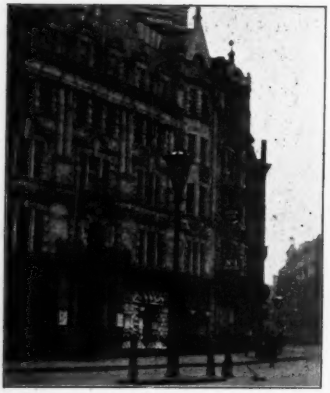


FIG. 1.



FIG. 2.



FIG. 3.



FIG. 4.

Fig. 1, Brush Open Type.

Fig. 2, Oliver & Gilbert.

Fig. 3, Angold Flame.

Fig. 4, Gilbert Flame.

Fig. 5, Angold Open Type

Fig. 6, Excello Flame.

Fig. 7, Oliver & Gilbert.



FIG. 5.



FIG. 6.



FIG. 7.

METHODS OF SUSPENDING ARC LAMPS IN THE STREETS OF ENGLAND.

CORRESPONDENCE.

The Moore Light.

January 20, 1908.

DEAR SIR,—I have read with interest Dr. Fleming's article in your last number, and there are two points in connexion with it that seem to me of interest.

Firstly, I should like to inquire whether Dr. Fleming has examined the spectrum of the light at the Savoy Hotel or the Moore carbon dioxide tube. Mr. Moore has stated that the latter approaches daylight very closely in spectrum composition, and has even recommended its use as a standard of white light on this account.

Yet I have always understood that luminescent rarefied gases yield discontinuous spectrum, which only becomes continuous when the gas in the tube is subjected to pressure so as to bring the atoms closer together and produce forced vibrations. If this is so in the case of the carbon di-oxide tube, I do not understand how colours illuminated by it can appear the same as daylight. If on the other hand the carbon dioxide tube gives a continuous spectrum, there must seemingly be something peculiar about the nature of the Moore discharge different from the discharge in the ordinary exhausted tube, to account for this fact.

The second point I wish to refer to is Dr. Fleming's statement that the inverse square law does not apply to the Moore tube. Naturally, as Dr. Fleming says, the calculation on page 25 cannot give correct information as to the illuminating power and the sources in practice. For this calculation assumes that all the light is concentrated at one point, and that therefore all portions of the light-giving surface are equidistant from the illuminated one. Whereas, it is in reality spread over a tube 176 feet long.

I imagine, however, that it is only the extensive area of the light-giving surface which renders the inverse square law inapplicable. Presumably there is not (as I have seen suggested) anything peculiar about the manner in which the rays of light are emitted from the tube, and the inverse square law would apply all right if a sufficiently small area of the tube was used.

I am, yours truly,

I. WANTERNO.

TRADE NOTES.

TANTALUM LAMP.—Messrs. Siemens Bros. inform us that they are now introducing a 16 c.p. Tantalum lamp, suitable for 100 to 120 volts, which is not more fragile than other types of Tantalum lamps, and will burn in any position.

WESTMINSTER ELECTRIC TESTING LABORATORY REPORT.—The Westminster Electrical Testing Laboratory are issuing a printed report of life tests carried out on a dozen different makes of glow lamps. The price of the report is 2*l.* 2*s.*, additional copies being procurable at a cost of 1*l.* 1*s.*

'ELECTRICIAN' 'ELECTRICAL TRADES DIRECTORY.'—We are requested to state that the 1908 edition of the above directory is now in course of completion, and that particulars intended for inclusion in the same should be forwarded at once to the publishing office.

REVIEWS OF BOOKS.

PRAKTISCHE PHOTOMETRIE.

By Dr. E. Liebenthal.

(*Published by Friedrich Vieweg & Son, Brunswick.*)

In the preface of this work Dr. Liebenthal remarks that the recent progress in the subject of photometry has been so rapid that the earlier works of Krüss, Palaz, and Stine, which answered their purpose at the time of publication, no longer suffice.

He has therefore endeavoured to undertake a more exhaustive treatment of the subject, for which Dr. Liebenthal's long experience at the Reichsanstalt eminently fits him. The completeness of this book will be gathered from the fact that it covers nearly 450 pages.

In the first three chapters the fundamental ideas of illumination are dealt with, coupled with a brief discussion of the physiology of the eye as it affects photometry, and a résumé of recent work on the subject of radiation. In the third chapter, for instance, there is a brief discussion of the most modern theories of colour-vision. The work of Lummer and Pringsheim on the radiation of the black body also receives treatment, and the distinction between luminescence and temperature-radiation is duly brought out.

The author next enters into the discussion of the chief photometric standards, his own well-known work on the Hefner and pentane standards finding due expression. The relations between the various standards of light are expressed in tabular form, and the definitions of the chief photometrical quantities are briefly explained.

The fifth chapter is given up to the subject of colour photometry, and includes a discussion of the various photometers which have been devised in order to meet the difficulties of the subject. This is brought up to date by the inclusion of a description of the chief types of flicker-photometers. A valuable addition to the treatment of this subject is an up-to-date chapter on spectro-photometry.

The eighth, ninth, tenth, and eleventh chapters deal very fully with the practical aspects of photometry, and are of special interest. The author discusses the measurement of mean spherical and mean horizontal candle-power, the so-called integrating photometers, and the efficiency and distribution and light from various sources, the subject matter being illustrated by many clear and adequate diagrams.

The remaining chapter contains a summary of directions covering various aspects of photometric testing in different countries,

On the whole Dr. Liebenthal has succeeded in producing what is probably the most exhaustive textbook on the subject of photometry as yet in existence, and the book should prove of great value to the student of this subject.

PRACTICAL ILLUMINATION.

By James Raley Cravath and Van Rensselaer Lansingh.

(*The McGraw Publishing Co., New York.*)

In this book, in which a series of articles recently appearing in *The Electrical World* are collected together, the authors deal in a simple and attractive manner with the practical application of light to the illumination of various kinds of buildings, including theatres, churches, shops, factories, &c. The book should be found of great value by those concerned with the practical aspect of illumination, as it treats the subject from a thoroughly practical and commonsense point of view, and is written in a lucid and interesting manner. One feature which deserves special commendation is a number of excellent diagrams and photographs by which the subject matter is illustrated.

Special attention is paid by the authors to the question of the use and value of concentrating or diffusing globes and reflectors in order to produce any desired effect. The numerous curves showing the relative values of the different kinds of globes and reflectors now commonly in use will be found very instructive.

We would have liked the book to have contained more numerical details giving the exact degree of illumination which must be provided for different purposes. This, however, will doubtless be remedied as the practical side of illumination reaches a more advanced stage. This book should not fail to attract the attention which it deserves from those in this country who are studying the problems dealt with therein.

Review of the Technical Press.

Illumination.

The recent paper by Dr. Louis Bell, before the American Academy of Arts and Sciences has been reproduced in the English technical papers. The ground covered by Dr. Bell's admirable paper is too great to be referred to in any detail here. The author deals with the values of "Fechner's Constant" at different Intensities of Illumination. He also discusses the connexion between the area of the pupil orifice and the intensity of the light striking the eye, and shows how violent contrasts of light and shade tire the eye, by causing successive adaptations to the two conditions.

He next turns to some complex questions of colour, and the question of acuteness of vision, pointing out how the want of achromatism of the eye enters into these problems. In this connexion he makes the interesting suggestion that the difficulty experienced in reading a book illuminated simultaneously by artificial and twilight illumination may be explained by the different accommodation of the eye to the two colours.

Dr. Monasch (*Jour. für Gas*, &c., Dec. 21, 1907) discussed the various methods of denoting units of intensity of illumination, and advocates the general adoption of the unit "lux," which is already very extensively used on the Continent. He also points out that the name of a unit ought not to be an attempt at definition such as is presented by combined expressions, such as "candle-foot" or "candle-metre," which inevitably lead to the multiplication of units and much confusion.

Several articles and papers have also appeared, in which the connexion of the principles of Architecture with Illuminating Engineering are discussed. In this connexion a recent paper before the Illuminating Society by Mr. Basset Jones has been much commented upon. Naturally both sides of the question must be considered, if we are to secure records of light which are tasteful and yet efficient. At present, however, it would seem that both sides have yet to learn to appreciate the other's point of view.

Some recent correspondence has taken place on the question of the correct method of specifying the desirable order of illumination for street-lighting, and in particular on the point whether this illumination should be measured exclusively in a horizontal plane or no.

Some object to this method, on the ground that we are very much concerned with the illumination of objects in a vertical plane. For instance, we may wish to be able to recognize a person walking down the street. Clearly the light falling upon his face would be ignored by measurements of horizontal illuminations only.

On the other hand, measurements other than those in the horizontal plane are subject to the drawback that the photometrical surface may frequently be illuminated by only a few of the sources which furnish general illumination. This view is taken by Mr. Roger T. Smith, who advocates horizontal measurements at a distance of 4 ft. above the ground.

Attention has also been drawn to a recent report by Dr. Kerr, Medical Officer to the L.C.C., who discusses the illumination of schoolrooms. The importance of this question cannot be gainsaid, and the simple rules of illumination on which Dr. Kerr insists deserve general recognition. Briefly, Dr. Kerr advocates even and adequate illumination over the schoolroom of not less than 1 candle-foot, the placing of sources of light so as to be outside the direct line of sight, and the separate treatment of the teachers' and scholars' portions of the schoolrooms. It is essential not only to secure satisfactory reading illumination for the children, but also to make special

provision for the teachers' needs, and the illumination of blackboards, diagrams, &c.

C. A. Baker (*Electrical Review*, Jan. 17, 1908) criticizes the illumination of Westminster Abbey, which he regards as not only unsuited to the needs of the congregation, but also not coming up to the æsthetic standard which the illumination of such a building demands.

Photometry.

The *Elektrotechnische Zeitschrift* for January 2 contains an interesting description of the photometrical laboratory of an arc lamp factory at Leipsic. The laboratories are very completely equipped for the measurement of high candle-power, and the taking of polar curves of distribution of light, and the illustrations show the use of the Ulbricht globe for obtaining values of the M.S.C.P. of arc lamps, &c. The globe shown in the illustration is no less than 3 metres in diameter, and it is a little surprising that such globes, which seem to be now regarded as thoroughly practical and serviceable bits of apparatus in Germany, have not found their way into any but very casual use over here.

Krüss (*Jour. für Gas*, &c., Dec. 28, 1907) describes some experiments, the main object of which was to obtain the distribution of light from the Hefner lamp and the relation between its horizontal and mean spherical candle-power. The distribution of light from such a source as the incandescent mantle can be calculated theoretically with very fair exactitude, but that of flames, owing to their transparent nature, cannot. Krüss finds that the candle-power of the Hefner flame, for example, falls off less rapidly on either side of the maximum value than theoretical calculation would suggest. He gives the M.S.C.P. as 0·89, the mean upper hemispherical candle - power as 0·94, and the mean lower hemispherical candle - power as 0·83.

Voege (*E.T.Z.*, Jan. 16, 1908), explains his method of applying the thermopile to the measurement of the distribution of light from a source. He points out that the obtaining of polar curves in the usual way is very laborious, and in the case of a fluctuating source, such as the arc light, not very accurate either. He states further that a sensitive thermopile, in spite of the fact that it measures energy and not light, may be used for the determination of the polar curves of such sources as the glow lamp, each portion of the filament of which radiates energy of the same character, and shows some curves of the tantalum and other lamps thus obtained. The application of the method to such sources as arc lamps is less evident, because in this case part of the light comes from the carbons, and part from the incandescent vapour, and it is uncertain whether the radiation from both would be of the same nature.

The author, however, claims to have minimized this difficulty by causing the light falling upon the thermopile to first pass through a thickness of clear glass and also a layer of green glass, which very largely absorbs the heat rays. He also arranges a reflecting galvanometer to throw a beam upon a suitable photographic screen, so that a record can be obtained of the variation of a source of light.

Tufts (*Physical Review*, Dec., 1907), investigates the curve of spectral luminosity of various observers, some colour-blind and others normal. He finds that the colour-blindness *may* influence the sensation of luminosity of an observer, but not necessarily so. In some cases a colour - blind observer would, therefore, obtain peculiar photometrical readings, but in others not. He also investigates the effect of prolonged exposure to light of one particular colour, and, contrary to the results of other observers, finds that the spectral curve of luminosity is not much affected thereby, except in the case of red light. Finally, he considers that his experiments, on the whole, support the contention that a distinct sense of *light* exists as distinguished from colour.

The Electrician for Jan. 24 contains a description of a form of universal photometer due to C. H. Sharp and P. S. Millar. The instrument may be used either for the measurement of candle-power or illumination. It depends upon the inverse square law, but the range of the instrument is increased by the use of either of two absorption screens, absorbing 90 per cent. and 99 per cent. of the light striking them respectively. In this way a range of 0·004 to 2,000 foot-candle can be measured. It is also claimed that the instrument is specially suitable for rapidly executed measurements, and in proof of this, a series of readings of the candle-power of an arc lamp during the space of ten minutes are given.

The Gas World and *The Journal of Gaslighting* contain further abstracts of the report of the American Gas Institute previously mentioned.

In the most recent bulletins of the Société Internationale des Electriciens,

M. Laporte gives a résumé of the decisions of the International Commission of Photometry, and also particulars of the exact recognized dimensions of the standard Carcel lamp.

ELECTRIC LIGHTING.

Loring (*Electrical World*, Jan. 4, 1908) discusses the metallic filament lamps, drawing special attention to the fact that their alteration in candle-power for a given alteration in P.D. is less than in the case of lamps of the carbon variety. This at first seems inconsistent with the view expressed by those (Prof. Niethammer, for example) who have shown that the metallic lamps are particularly susceptible to small variations of voltage. In reality there seem to be two separate points to be considered. It is true that a certain definite and permanent change in pressure alters the candle-power of a metallic filament less than the carbon one. On the other hand, it must be remembered that the low specific heat of the metallic filament renders it more liable to lose its temperature and so alter in candle-power, owing to very rapid temporary changes in voltage, and on this account may be found to "flicker" more on an unsteady supply than the carbon lamp.

A technical discussion of the chemical and physical aspects of the process of graphitizing filaments is to be found in the *Zeitschrift für Beleuchtungswesen* for Jan. 10. It would appear that the chief point to be gained by special treatments of the carbon filament is the rendering the pores in the material as small as possible. By so doing the influence of the escaping gases from the filament and their presumable deteriorating effect are reduced to a minimum.

Böhm has also compiled an exhaustive and useful résumé of recent patents on the subject of the metallic filament lamps.

Several articles on the subject of arc lighting have recently appeared.

Krause and Dyott deal with arc lighting in general and the magnetite arc respectively. *The Illuminating Engineer* for December contains an interesting description of the application of an ingenious form of inverted arc light to the colour-printing room of the Curtis Publishing Co. The light from the arc itself is thrown up on to a concentric diffusing reflector, forming part of the lamp. In addition to the merit of being easily cleaned, the reflecting surface above the lamp can be tinted any desired shade, and in this case special efforts have been made to secure just such a tint as to produce reflected light exactly resembling daylight in colour. It is said that this method is so successful, that colours can be matched by the light with the same certainty as by daylight.

GASLIGHTING, &c.

Mr. F. W. Goodenough, in a recent lecture on shoplighting, drew attention to the merits of gas for this purpose, and incidentally emphasized several simple but vital points in shoplighting. He gave some simple rules for general lighting, on the basis of so many candle-power per cubic foot of contents of shop, and per foot run of shop frontage, and impressed upon his hearers the necessity for attending to the maintenance of burners, &c., and allowing them plenty of pressure, and mentioned some cases in which gas had been installed with very satisfactory economical results.

Mr. H. Butterfield (*Journal of Gaslighting*, Jan. 17) described an installation which had been converted from low to high pressure on the Keith system.

Wedler (*Jour. für Gas*, &c., Dec. 28, 1907) gives some details of the application of incandescent mantles to train lighting. The great difficulty in the way of the general application of incandescent mantles to this purpose has hitherto been the fragility of the mantles, but now that their strength has been very much improved, they are finding more application. Inverted burners are specially suited for carriage illumination in one respect, namely, owing to the fact that no shadow is thrown by them, as is the case with the upright type. On the other hand, they have a tendency to break and fall from their holders in time, and when this happens the passenger may be left without any light. To guard against this contingency, an Austrian company provide a cock which in an emergency can be turned on, so as to provide a second light. On one of the French railways a mantle only lasts 17 days, but it must be added that these mantles are in use for 18 hours each day. On the Prussian lines a mantle usually lasts 50 to 60 days.

Acetylene for January contains some interesting notes on the value of acetylene for lighthouses, buoys, &c. In this connexion the report of Capt. Ross of the United States navy is quoted. Acetylene for buoys, &c., claims the advantages that more light can be obtained than from the same volume of gas, that the apparatus is more portable, especially owing to the fact that relatively

little pressure is needed, and that when over 10 atmospheres pressure is used for the compression of gas the heavier hydrocarbons begin to condense as oil, and the richness of the gas from an illuminating point of view is diminished thereby. Some attention is also given to the use of acetylene, chiefly in France, with incandescent mantles. A difficulty which some appear to find at present is that the adjustment of the burners, which have to be specially constructed, is rather too delicate for the average householder to handle.

ILLUMINATION.

Baker, C. A. The Lighting of Westminster Abbey (*Elec. Rev.*, Jan 17).
Basset Jones, W. "The Relation of Architectural Principles to Illuminating Engineering Practice (*Elec. Rev.*, Dec. 21, 1907 ; see also Editorial).
Bell, Louis. The Physiological Basis of Illumination (*Proc.* Am. Acad. of Arts and Sciences September, 1907, abstracted *Jour. of Gaslighting*, Dec. 17, 1907).
Street Lighting and New Illuminants (*Elec. World*, Jan. 11, 1908).
Editorial. The Illuminating Engineer (*Electrician*, Dec. 20, *Gas World*, Dec. 14, 1908).
Foel, O. The Distribution of Light (*Trans.* Illum. Eng. Soc., November, 1907, abstracted *Elec. Rev.* N.Y., Jan. 4, 1908).
Lansingh and Heck. Fixture Design from the Standpoint of the Illuminating Engineer (*Trans.* Ill. Eng. Soc., Dec., 1907).
Monasch, B. Die Unerträglichkeit der gegenwartigen internationalen Bezeichnungsweise für Beleuch-tungswerte (*Jour. f. Gas*, &c., Dec. 21, 1907).
Niemann and Du Bois. Zur Entwicklung des Beleuchtungswesens (*Zeit. für Bel.*, Dec. 14, 1907).
Sharp, C. H., and Millar, P. S. Experimental Data on Illuminating Values (*Elec. Rev.* N.Y., Dec. 21).
Smith, R. T., &c. The City Lighting and the Measurement of Illumination (*Elec. Rev.*, Dec. 20 and 27, 1907, and Jan. 17, 1908).
The Lighting of Schools (*Elec. Rev.*, Jan. 3, *Elec. Engineering*, Jan. 2, *Elec. Engineer*, Jan. 17, 1908).
The Cost of Various Illuminants (*Lumière Electrique*, Jan. 11, 1908).

PHOTOMETRY.

Hyde, E. P., and Cady, F. A Comparative Study of Plain and Frosted Lamps (*Bull.* Bureau of Standards, U.S.A., Vol. 4).
Kruss, H. Die Polarkurve der Hefnerlampe (*Jour. für Gas*, &c., Dec. 28).
Laporte, H. La Commission Internationale de Photometrie (*Soc. Int. Bull.*, Nov. and Dec., 1907).
Sharp, C. H., and P. S. Millar. A New Universal Photometer (*Electrician*, Jan. 24, 1908).
Tufts, F. L. Spectrophotometry of Normal and Colour-blind Eyes (*Phys. Rev.*, December).
Voege, W. Ein neues Verfahren zur Aufname der Lichtverteilungskurve und des Gleichformigskeitsgrades kunstlicher Lichtquellen (*E. T. Z.*, Jan. 16, 1908).
Moderne Photometriereinrichtungen (*E. T. Z.*, Jan. 2, 1908).
Report of the Am. Gas Institute on Testing Gas for Candle Power (*Gas World*, Jan. 11, *Journal of Gaslighting*, Jan. 14, 1908).
A Selenium Photometer (*Elec. Rev., N.Y.*, Dec. 14).

ELECTRIC LIGHTING.

Blondel, A. Recent Progress in Flame Arc Lamps (*Bull. Sec. Int. Elec.*, March, 1907, abstracted, *Electrician*, Dec. 20.
Böhm, C. R. The Electric Conductivity of Carbides, &c. (*Am. Ill. Engineer*, Dec., 1907, and Jan., 1908).
Dyott, G. M. The Characteristics of the Magnetic Arc (*Elec. World*, N.Y., Dec. 7, 1907.
Krause. Some Notes on Arc Lighting (read before the Junior Institution of Engineers (Dec. 10, 1907).
The Lighting of the Colour Press Room at the Curtis Publishing Co. (*American Illuminating Engineer*, Dec., also *Elec. World*, Jan. 11).
Loring, G. Some facts regarding Metal Filaments (*Elec. World*, Jan. 4).
Hopfelt, R. Einiges über die Kohlenfaden Lampen-fabrikaton (*Zeit. für Bel.*, Jan. 10).
Vogel, O. A Criticism on the Mercury Vapour Lamp (*Gas World*, Dec. 21, abstracted).
Betrachtungen über die heutigen Stand des Quecksilber Lampenbaues (*Elek. Anz.*, Dec. 22 and 29, 1907).

GASLIGHTING, ETC.

Butterfield, H. High Pressure Gas Lighting (*Journal of Gaslighting*, Jan. 17, 1908).
Dettman, G. Die angebliche Gefahrlichkeit des Leuchtgases in Lichte statischen. Thatsachen (*Jour. für Gas*, &c., Dec. 7, 1907).
Goodenough, F. W. Shoplighting by Gas (*Jour. of Gaslighting*, Jan. 17, 1908).
Kern. Distance Lighting (from the *Jour. für Gas*, &c., abstracted in the *Gas World*, Dec. 21, 1907).
Little, T. J. Show-window Lighting by Gas (*Am. Ill. Engineer*, Jan., 1908).
Wedler. Invert Gasglühlicht zur Eisenbahnwagenbeleuchtung (*Jour. für Gas*, &c., Dec. 28, 1907).
Whitaker. Inverted Gas Lighting (*Trans.* Ill. Engineer Soc., Dec., 1907).
The Use of Acetylene for Lighthouses and Buoys (*Acetylene*, Jan., 1908).
Uber Versuchen an den Lübecken Gasferneinleitungen (*Jour. für Gas*, Nov. 30, 1907

On the Theory of the Incandescent Mantle.

(From the *Zeitschrift für Beleuchtungswesen.*)

In this note the author comments on some of the previous speculations on the theory of the incandescent mantle, by H. W. Fischer (*Sammlung chemischen und chemische-technischen Vorträge*, Band XI., Heft 4).

Fischer refers, firstly, to the now well-known fact that the incandescent mantle is most efficient when containing about 0·8 per cent. of Cerium, and the remainder pure Thorium. He emphasizes the point, also, that very small amounts of impurities have a notoriously bad effect on the light from the mantle, and that iron and præso-didymium are particularly effective in this respect. He then passes on to discuss the rival theories of luminescence and temperature-radiation, and favours the view that the radiation from the mantle is of the latter variety.

To decide this point experiments on the external heating of black bodies have been devised. If, for instance, a foreign body is placed inside a heated porcelain tube, so as to be completely enclosed except for a very small opening, and if, after temperature-equilibrium is attained, the foreign body vanishes optically, then we can assume that we are dealing with temperature-radiation. This method was followed by St. John, who, however, did not work with the mixture utilized in mantles, but with certain other rare earths, so that, in his case, although the foreign body vanished optically, the result might not be rigidly applicable to the incandescent mantle.

More recently Dr. Bunte was able to make the material of an incandescent mantle vanish in this way. Yet, even so, we have only proved the non-existence of thermal, and not chemical luminescence. The incandescent mantle glows in the Bunsen flame, which is known to be rich in ultra-violet rays, and these rays easily set up chemical luminescence. In the black body experiment, the temperature was only 1,600 to 1,800 degrees centigrade, so that the maximum energy of the curve would be right out in the infra-red, and very little ultra-violet light would be present.

On the other hand, there are important grounds for believing in the existence of luminescence in the mantle, some of which are as follows :—

1. The incandescent body still glows for an appreciable time after the flame is withdrawn.

2. The rare earths exhibit luminescence under the action of cathode rays, but only when they contain small impurities of the order of the percentage of Cerium included in incandescent mantles. Whether it has been shown that *pure* rare earths luminesce in this way is uncertain.

3. There is reason to suppose that, when dealing with a mixture of Cerium and Thorium, we have a stable solution, in the sense of Van T'Hoff, and many such stable solutions show luminescence : for instance, combinations of the alkaline earths, zinc, magnesium, and small quantities of the corresponding salt of manganese, &c.

4. The Bunsen flame, as we have seen, is rich in ultra-violet light, and these rays are known to cause luminescence, and are, indeed, often recognized by means of the exhibition of fluorescent properties.

5. It is known that the addition of small quantities of iron to a luminescent stable solution may suppress the luminescence. Now, if an incandescent mantle is soaked in ink, it loses its luminosity almost entirely, in consequence of glowing iron oxide. If one regards the light from an incandescent mantle as due to temperature-radiation, this fact is very imperfectly explained by the black-body law.

6. The mechanical equivalent of light of an incandesent mantle is in the neighbourhood of 0·04 watts per H.K., very nearly the same value as the mechanical equivalent of light from the arc light, in which, it is believed, temperature and other forms of radiation take place simultaneously. In the case of pure temperature-radiation, as, for instance, the flames composed of glowing incandescent carbon, and the carbon filament glow-lamp, the mechanical equivalent is in the neighbourhood of 0·08 to 1 watts per H.K.

The general evidence against the supposition that the action of the incandescent mantle is due to pure temperature-radiation is so weighty that even Herr Fischer cannot be said to dispose of it.

PATENT LIST.

PATENTS APPLIED FOR.

I.—ELECTRIC LIGHTING.

27,076. Incandescent lamps. Dec. 7, 1907. J. H. Hegner, 16, Place de la République, Paris.
27,130. Incandescent lamps. Dec. 7, 1907. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
27,132. Arc lamps. Dec. 7, 1907. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From Allgemeine Elektricitäts-Ges., Germany.)
27,223. Arc lamp. Dec. 9, 1907. The British Thomson-Houston Co., Ltd., and W. H. Dalton, 83, Cannon Street, London.
27,412. Arc Lamps. Dec. 12, 1907. H. Bevis and A. E. Angold, Peel Works, Adelphi, Salford.
27,497. Metallic incandescent bodies for glow lamps. Dec. 13, 1907. H. W. Purle, 17, Denver Road, Stamford Hill, London.
27,541. Incandescent lamps (C.S.). Dec. 13, 1907. C. Pauli, 20, High Holborn, London.
27,809. Incandescent lamps (C.S.). Dec. 17, 1907. E. C. R. Marks, 18, Southampton Buildings, London. (From Parker-Clark Electric Co., U.S.A.)
28,175. Arc lamps. Dec. 21, 1907. F. M. Lewis, 11, Buckingham Road, Brighton.
28,291. Incandescent lamps. Dec. 23, 1907. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
28,451. Lengthening life of incandescent lamps (C.S.). Dec. 27, 1907. W. Herrmann, 40, Chancery Lane, London.
2. Portable lamp. Jan. 1, 1908. T. Shepherd, 20, Martineau Street, Birmingham.
66. Arc lamp electrodes. Jan. 1, 1908 (I.C. Jan. 5, 1907, U.S.A.). G. M. Little, Westinghouse Patent Bureau, Norfolk Street, Strand, London.
461. Incandescent lamps. Jan. 8, 1908. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
732. Incandescent lamps. Jan. 11, 1908. The British Thomson-Houston Co., Ltd., and H. H. Needham, 83, Cannon Street, London.

II.—GAS LIGHTING.

27,127. Incandescent mantles. Dec. 7, 1907. B. Young, 129, The Grove, Wandsworth, London.
27,137. Inverted incandescent lamps. Dec. 9, 1907. P. Wigley, G. N. Arculus, and J. Warry, trading as Alfred Arculus & Co., 128, Colmore Row, Birmingham.
27,367. Manufacture of incandescent mantles. Dec. 11, 1907. W. G. Head, 6, Bream's Buildings, London.
27,455. Inverted incandescent lamps. Dec. 12, 1907. S. G. How and E. S. Wright, 6, Bream's Buildings, London.
27,679. Inverted incandescent burner. Dec. 16, 1907. H. Pullen, 27, Listerhills Road, Bradford.
28,301. Inverted mantles and fittings for same. Dec. 23, 1907. G. H. Barber and S. R. Barrett, 18, Southampton Buildings, London.
28,360. Gas lamps. Dec. 24, 1907. J. Keith and G. Keith, 65, Chancery Lane, London.
28,393. Inverted incandescent lamps. Dec. 24, 1907. S. Biheller, 1, Great James Street, Bedford Row, London.
28,462. Inverted burners and lamps. Dec. 27, 1907. W. G. Potter, 14, Ingleton Street, Brixton, London.
28,519. Inverted burners. Dec. 28, 1907. W. H. Wood, 32, Warwick Road, Sparkhill, Birmingham.
227. Appliances for use with incandescent lamps. Jan. 4, 1908. S. A. Jackson, 317, Regent Road, Salford, Lancs.
350. Inverted incandescent burners. Jan. 6, 1908. F. Turner and G. Hands, trading as G. Hands & Co., 77, Chancery Lane, London.

III.—MISCELLANEOUS.

(Including lighting by unspecified means, and inventions of general applicability.)

27,581. Lamps for church, synagogue, and like uses. Dec. 14, 1907. M. Shrensky, 55, Market Street Manchester.
28,245. Acetylene burners. Dec. 23, 1907. A. Bray, Sunbridge Chambers, Bradford, Yorks.
28,495. Lamps. Dec. 27, 1907. Clarke's "Pyramid" and "Fairy" Light Co., Ltd., S. B. Clarke, and H. Clarke, 24, Southampton Buildings, London.
28,707. Lighting streets, docks, warehouses, railway stations, &c. Dec. 31, 1907. O. Hellstern and G. T. Vincent, 1, Ranelagh Gardens, Barnes, London.
330. Lamp shade (C.S.). Jan. 6, 1908 (I.C. Jan. 11, 1907, U.S.A.). W. O. Holt and R. L. Foster, 173, Fleet Street, London.
391. Incandescent lamps. Jan. 7, 1908. J. Stott, 62, Grains Road, Shaw.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

23,009. Arc lamps. Oct. 17, 1906. Accepted Dec. 27, 1907. The British Thomson-Houston Co., Ltd. and W. H. Dalton, 83, Cannon Street, London.

24,179. Incandescent lamps. Oct. 30, 1906. Accepted Dec. 11, 1907. F. W. le Tall, 2, Norfolk Street, Strand, London. (From A. Lederer, Austria.)

27,725. Arc lamp with inclined carbon holders. Dec. 5, 1906. Accepted Dec. 11, 1907. J. Brockie, Birkbeck Bank Chambers, London.

28,775. Metallic incandescence bodies for glow lamps. (I.C. March 27, 1906, Germany.) Accepted Dec. 18, 1907. Deutsche Gasglühlicht Akt.-Ges. (Auerges), 55, Chancery Lane, London.

29,758. Systems of train lighting. Dec, 31, 1906. Accepted Dec. 31, 1907. H. Leitner, 4, South Street, Finsbury, London.

155. Incandescent lamps. Jan. 3, 1907. Accepted Jan. 8, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From the General Electric Co., U.S.A.)

521. Inclined-carbon arc lamps. Jan. 8, 1907. Accepted Jan. 8, 1908. E. Pearce and S. Walton, Norfolk House, Norfolk Street, Strand, London.

15,017. Incandescent lamps with metal filaments (C.S.). June 29, 1907. Accepted Dec. 27, 1907. H. Kuzel, 322, High Holborn, London.

17,973. Filaments of refractory metals (C.S.). Aug. 7, 1907. Accepted Dec. 11, 1907. A. G. Bloxam, Birkbeck Bank Chambers, London. (From Siemens & Halske, Germany.)

18,923. Incandescent lamps (C.S.). I.C. Nov. 23, 1906, Germany. Accepted Dec. 11, 1907. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Building, Norfolk Street, Strand, London.

19,829. Reflector incandescent lamps (C.S.). Sept. 5, 1907. Accepted Jan. 15, 1908. H. Gilmore, Old South Building, Boston, Mass.

26,846. Arc lamps (C.S.). I.C. Dec. 5, 1906, Germany. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.

27,739. Arc lamp (C.S.). I.C. Dec. 20, 1906, Germany. F. Janecek, 27, Chancery Lane, London.

28,138. Lamps (C.S.). I.C. Dec. 27, 1906, Germany. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.

66. Arc lamp electrodes (C.S.). I.C. Jan. 5, 1907, U.S.A. G. M. Little, Westinghouse Patent Bureau, Norfolk Street, Strand, London.

II.—GAS LIGHTING.

19,753. Incandescent burner. Sept. 5, 1906. Accepted Dec. 18, 1907. H Fischer, 24, Meineckestrasse, Post Office 15, Berlin.

28,094. Lighting gas at a distance. Dec. 01, 1906. Accepted Dec. 18, 1907. H. Birnbach, 19, Farringdon Street, London.

28,213. Incandescent lamps. Dec. 11, 1906. Accepted Dec. 11, 1907. A. G. Smith, 34, Castle Street, Liverpool.

1,577. Incandescent burner. Jan. 21, 1907. Accepted Dec. 11. F. Kratky, 65, Chancery Lane, London.

4,112. Inverted incandescent burners. Feb. 19, 1907. Accepted Dec. 27. W. Anderson and H. Anderson, 41, Reform Street, Dundee.

6,322. Gas light apparatus. March 15, 1907. Accepted Jan. 15, 1908. J. W. Hardt, 65, Chancery Lane, London.

8,323. Incandescent burners. April 10, 1907. Accepted Dec. 18. J. W. Bray, Sunbridge Chambers, Bradford.

8,330. Inverted lamps. April 10, 1907. Accepted Dec. 27. S. Biheller, 1, Great James Street, Bedford Row, London.

8,331. Lamps or lanterns for incandescent lighting. April 10, 1907. Accepted Dec. 27. S. Biheller, 1, Great James Street, Bedford Row, London.

13,665. Inverted incandescent burners for railway carriages, &c. June 13, 1907. Accepted Dec. 18. F. W. Marillier and T. Stanton, Engineer's Office, Great Western Railway, Swindon.

14,317. Incandescent burners. June 21, 1907. Accepted Jan. 15, 1908. T. Thorp, 57, Barton Arcade, Manchester.

15,776. Inverted incandescent lamps (C.S.). I.C. May 18, 1907, Germany. Accepted Dec. 18. C. Reiss, 18, Southampton Buildings, London.

16,867. Incandescent mantles (C.S.). July 23, 1907. Accepted Jan. 15, 1908. H. Süssman, 1, Great James Street, Bedford Row, London.

19,278. Inverted incandescent burners (C.S.). Aug. 27, 1907. Accepted Dec. 31. J. Altman, 322, High Holborn, London.

22,403. Catalytic lighting appliances (C.S.). I.C Oct. 12, 1906, Germany. Accepted Dec. 18, 1907. G. Salomonsohn, 6, Lord Street, Liverpool.

27,939. Incandescent mantles (C.S.). I.C. Dec. 18, 1906, Germany. W. Huber, 72, Cannon Street, London

III.—MISCELLANEOUS.

(Including lighting by unspecified means, and inventions of general applicability.)

3,621. Incandescent petroleum lamps. Feb. 13, 1907. Accepted Jan. 15, 1908. A. B. Krzywiec, 6, Lord Street, Liverpool.

5,916. Lighting lighthouses, &c. March 12, 1907. Accepted Dec. 18. C. A. Stevenson, 28, Douglas Crescent, Edinburgh.

17,838. Incandescent spirit lamps (C.S.). Aug. 6, 1907. Accepted Dec. 18. W. Lauda and H. Wictorin, 91 Lindenallee, Essen-on-the-Ruhr, Germany.

19,344. Incandescent lamp for liquid fuel (C.S.). Aug. 28, 1907. Accepted Dec. 18. A. Mathieu, 7, Staple Inn, London.

19,473. Acetylene lamps (C.S.). I.C. Aug. 31, 1906, Germany. Accepted Dec. 31, 1907. E. Schichtmeyer, 111, Hatton Garden, London.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

Accepted.—Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

[The Editor of 'The Illuminating Engineer' does not necessarily identify himself in any way with the opinions expressed by his Contributors.]





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EDITORIAL.

WE take this opportunity of expressing our acknowledgment of the invariable kindness with which the first two numbers of 'THE ILLUMINATING ENGINEER' have been greeted. This shows that our conviction of the necessity for a journal dealing solely with matters of illumination was well-founded. We think that the present number should be found of equal interest.

The article by Dr. Hubert Biss on the preservation of the eyesight of school-children will be read with interest by those who have followed the discussion of eyesight and illumination which formed the subject of the special section in our first number. Dr. Biss's remarks should serve to show that the importance which we have attached to the improvement of lighting conditions in the schools is fully shared by the medical profession, and that we have not over-emphasized the gravity of the whole question.

M. Pihan's description of the method of testing coloured glasses intended for signal-lamps is also of exceptional interest, as an illustration of a case in which colour-phenomena become of very great consequence. For the appearance of distant coloured signals is necessarily controlled by physiological effects. The exact point at which a signal becomes indistinguishable is dependent on the behaviour of the retina of the eye on which the image of these coloured objects is received.

Also the classification and selection of glasses intended for such purposes should, as M. Pihan truly points out, be subjected to careful and scientific study, and this, again, involves a knowledge of the scientific sides of the subject.

The varied nature of the other interesting articles in this number will serve to convey some impression of the wideness of the field covered by the work of the illuminating engineer, and do not require special mention.

Illuminating Engineering and the Architect.

In a previous number we dealt with the influence of good and bad illumination on eyesight—a matter of the greatest moment to oculists.

There is, however, another aspect of illumination on which we lay stress in our present number, which must also be recognized as worthy of special study.

The æsthetic aspects of illumination, with which the architect is very closely concerned, have certainly not received the attention they deserve. It is unquestionably true that the intentions of the architect are frequently defeated by the adoption of some tasteless and defective system of illumination, which quite fails to bring out the æsthetic and architectural features of a room or building to the best advantage.

When we take the broad standpoint that it is only by means of light that we are able to see surrounding objects at all, the importance of the careful utilization of this light is evident.

The general scheme of decoration of an interior being left to the architect, he is, naturally, concerned with the nature of the illumination employed to display it. Conversely, the scheme of decoration has a very marked influence on the order of illumination which the lighting engineer can expect to secure from a certain choice of lights. Dark-coloured wall-papers and surroundings, for instance, reflect but a fraction of the light falling upon them, and necessitate a corresponding increase in the intensity of the sources employed.

There is, therefore, every reason to advocate the co-operation of those who are chiefly concerned with the satisfactory use of light from a utilitarian point of view, and those who are interested in securing illumination which is pleasing æsthetically.

Nor is there any real reason why these two aims should clash. It is true that many decorative devices and fittings in use at the present time would be rightly condemned by the expert in illumination as inefficient, because they absorb a considerable amount of light, or distribute it in directions where it is not needed. Yet it should certainly be possible by judicious design to secure lighting conditions which are both efficient and artistic.

At present, however, the data available as to what really constitutes effective artistic lighting are very meagre, especially when we bear in mind the varying nature of the requirements of different types of buildings.

International Notation.

The letter from M. Laporte on this question in our present number shows how readily different conceptions as to the meaning of photometrical terms—even those which have been the subject of careful deliberation and definition—may prevail in different countries. Briefly, M. Laporte's contention is that the "lux," as understood in France, is defined in terms of the French standard, and is therefore understood in a different sense from that advocated by Dr. Monasch, who has naturally been guided by the German standpoint in suggesting the adoption of "lux" as synonymous with Hefner-metre.

All these are questions on which general agreement is now recognized to be essential, but there is a great need of a tribunal sufficiently exalted and appreciated to impose conditions which will meet with general recognition.

Satisfactory conclusions on these points can only be arrived at by conference, not only between those representing the different aspects of illumination in the same country, but also those representing different nationalities.

The excellent work accomplished by the International Commission on photometry is largely due to its

essentially international character. Yet, as Dr. Monasch has succeeded in showing, its recommendations are very frequently not carried out at present even by competent and responsible writers.

Increasing efforts are being made to put professional and national bias aside and consider these problems in a scientific and impartial manner. We have already referred to the work of the International Photometrical Commission. We note, too, that in Germany the recommendations of this commission receive the united consideration of the Verband Deutscher Elektrotechniker, the Vereinigung der Elektricitätswerke, and the Verein der Gas- und Wasserfachmänner—a very pleasing illustration of the truth of our contention that there is no real obstacle in the way of those representing the gas and electric interests coming together to discuss matters of mutual interest. Similar efforts are being made in the United States. We have been informed by Mr. Marks, who last year was the first President of the Illuminating Engineering Society, and whose letter we reproduce elsewhere, that the American Institution of Electrical Engineers and the American Gas Institute have both appointed committees to meet the Committee on Nomenclature and Standards of the Illuminating Engineering Society, with a view to agreement on a suitable standard of light.

It appears to us desirable for the efforts of the various committees at work on the subject to be subjected to yet further concentration. This is rendered the more essential by the fact that there also exists the very fully representative International Electrotechnical Commission, which is considering the possibility of extending its work to questions of light measurement. From the point of view of national representation, this commission is probably unique, in that executive committees have already been formed or are in process of formation by no less than eighteen nationalities and colonies, including the United States, Canada, South Africa, Australia, Japan, and the chief European countries.

The machinery available is therefore, in one sense, excellent for the purpose in view, but it would be unfortunate if a fresh effort at standardization were to be made which did not utilize the deliberations of other existing commissions.

In this connexion it may be mentioned that the sub-committee dealing with symbols, &c., is bearing in mind the recommendations of the International Photometrical Commission.

A comprehensive system of symbols covering the various appliances used in wiring and plumbing, which ought to find a place in suitable plans before installation, is also badly needed. The list of symbols recommended by the American Illuminating Engineering Society, which we reproduce in this number, is therefore well worthy of study.

The services which the International Electrotechnical Commission is rendering to the electrical industry are exceedingly great. We see no reason why the existing organization should not be applied to the standardization of the quantities and symbols to which we have referred, and which we consider to be of the very greatest interest not only to the illuminating engineer, but to the contractor and, indeed, all concerned with the improvement of existing methods of illumination.

The Application of the Thermopile to Photometry.

The question raised by the recent article by W. Voege abstracted in our present number—the problem, that is, of the application of so-called "Physical Methods" of measuring light to photometry—is of considerable interest. Such methods are usually dismissed by the photometric expert with the

declaration that they are merely devices for the measurement of radiant energy, and that, even when they do distinguish between radiant energy of different wave lengths, they do not do so in the same manner as the eye, which, of course, must always be the ultimate reference in photometrical measurement.

At the same time we need not consider this an insuperable obstacle. It is desirable that we should presently succeed in producing a physical photometer resembling an artificial eye in its treatment of light-energy. Voege has himself gone a little way in this direction by the use of suitable glasses in front of the thermopile. Such photometrical arrangements, if sufficiently accurate, would undoubtedly render possible a great saving in labour, and the thermopile arrangement here described seems very convenient in its application to one of the most tedious varieties of work with which photometric experts have to deal.

Yet we must own that we ourselves are impressed by the difficulties to which the author himself makes reference. Unless a thermopile can be used under conditions which preclude the possibility of undue preference being given to the heat rays, the method must be occasionally inaccurate. The curves given by the author for various illuminants certainly resemble those which are obtained by the usual photometric process: we note, however, what seems rather a surprising omission in an attempt to show the practical value of the method. The author does not actually show, side by side, curves of distribution of light obtained by a thermopile and also by a purely photometrical method. Such curves would be of great interest, and might go far to reassure those who are disposed to doubt the practical utility of the method.

One application of the method dealt with by the author seems to us of special value, and that is the study of the "steadiness" of different sources of light. The author says truly that there has hitherto been no really satisfactory method of observing fluctuations in the light from a source on account of the time necessary to carry out a photometric observation and the labour of taking a series of readings.

The application of the thermopile to this problem may be of great practical utility. Moreover, this seems to be a case in which the fundamental difficulties of the method are of less consequence, for it would seem that rapid fluctuations in the radiation from a source must co-exist with variation in the light emitted. Even here, however, errors and misconceptions might easily be introduced by the unscientific observer who was not on the look-out for possible abnormalities. It may be suggested, therefore, that such methods may be found chiefly useful by the skilled worker, well acquainted with the subjects of radiation and photometry.

The Legal Aspects of Gas-testing.

The recent judgment against the Brentford Gas Co., to which we make reference elsewhere, affords an interesting case of the incongruous results which may arise from the legal insistence upon the letter of an obsolete form of testing. Whatever be the purely technical aspects of such a case, one cannot help being struck by the anomaly presented by a law which insists that gas must be tested by a form of burner that is admitted to be obsolete and, judged by modern standards, defective in addition.

Mr. Grafton, in his recent contribution to our columns, was evidently impressed with the inconveniences of such a system, and contended that all that was necessary was the use of a burner that really yielded the maximum light from the gas tested. These, of course, are important points for the expert to settle. Leon Gaster.

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 97.)

Although cosines and their powers will often be mentioned, no trigonometrical work will be employed here. The practical application of this will be seen at once. In Fig. 8 a ray from a lamp at A on a pole AB, casting light

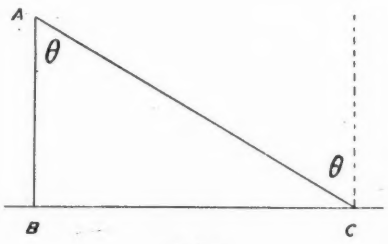


Fig. 8.

on the point C, makes the angle θ, the angle of incidence being the angle between the ray AC and the dotted perpendicular at the point C, or, what is the same thing, the angle between the ray and the perpendicular AB. The cosine is in this case the ratio of AB to the slant height AC. So long as the distance AC remains the same, the illumination at C will be in proportion to, or will vary as the cosine.

Mean Spherical Candle-Power.

Conceive a source of light to be surrounded by an imaginary sphere, and many points to be taken uniformly distributed over the surface of the sphere, and the candle-power to be measured in the direction of each of these points, then the average of all the measurements is the mean spherical candle-power. So long as the candle-power is sensibly the same in all *useful* directions, there is no advantage in considering the mean spherical candle-power. When the candle-power is widely different in different directions, as in the case of a continuous current open arc, the mean spherical candle-power gives very little useful information. It is like trying to describe the performance of a steam-engine by giving the mean pressure in the cylinder. On the other hand, for those who know the kind of distribution of light, as in the special case mentioned, the M.S.C.P. as it is called, is better than giving the maximum candle-power, as was the custom in the old arc-lamp days of the early eighties. Since such an arc gives practically no light at all in the upper hemisphere, the mean hemispherical

candle-power is sometimes used. The horizontal candle-power of ordinary electric glow-lamps does not differ more than about 15 per cent. from the M.S.C.P.

Flux of Light or Total Light.

There are three ways in which rainfall may be measured. The average annual rainfall on Great Britain may be described as 115,200 cubic feet, or 3,200 tons per acre; or as standing with a vertical section of 2·65 square feet on each lineal foot. (The flow of a river in cubic feet per second is found by multiplying the area of the vertical section in square feet by the average velocity in feet per second.) Or it may be simply stated as 32 inches. The first way employs three dimensions of water and two of land; the second suppresses one of each of these dimensions, and leaves two of water and one of land; the third way again suppresses one of each of the dimensions, and leaves one of water and none of land. The last is of the nature of an intensity.

It may be argued that the first is the true way, for it alone deals with a real quantity of water; and the other ways are abstractions. Similarly, it has been suggested that the true way to measure light is as a flow of luminous energy. But the difference is one of suppressed dimensions.

M. André Blondel, who has written so lucidly on photometric magnitudes and units,* cites an American story to show that the flux of light is instinctively felt to be the fundamental quantity in photometry, and that it is misunderstood simply because no name for a unit of it has been recognized. "An expert, called in to interpret a clause in an electric lighting contract between a town near New York and the local electrical company, with regard to some 2,000 nominal candle-power arcs, expressed his opinion as follows: 'The arc lamps are suspended at the cross roads, and each one, therefore, sends its light out in four directions; one cannot, therefore, expect to get 2,000 candles in each direction. The 2,000 candle arc arranged for in the agreement was one sending 500 candles down each road.' We do not wish to make fun of this expert," adds M. Blondel, "for in truth he is a very sensible man."*

A source of light capable of giving 1 candle-power in every direction, placed in the centre of a sphere of 1 ft. radius, will give an illumination of 1 foot-candle over the whole surface. That surface is 4π, or 12·56 square feet. Some writers have wrought great confusion by saying that the light of such a source is 4π candles, or 12·56 candles. No such photometric quantity as a "candle" exists. Their reasoning is generally in a circle, and they come back to ordinary candle-power again after a mess of unnecessary mathematics.

No enterprising lamp manufacturers could excuse themselves for offering lamps as "201 candles," by explaining that they give $4\pi \times 16$ candle-power. If we say that the flux is 4π times the candle-power we make no advance, and if we say that the "total light" is 4π candles we are likely to be misunderstood. We should, if possible, avoid introducing unnecessary dimensions if they have to disappear in the final result.†

In the case of electric arc lamps the candle-power varies in different directions in any vertical plane, but, except for accidental irregularities, it is the same in each such plane. If the candle-power at various angles with the horizon is measured, the mean spherical candle-power may be calculated by certain methods which will

* *The Electrician*, vol. xxxiii. p. 633, Sept. 28, 1894.

* I told this story to a very intelligent lady, and, by request, repeated it three times. She said, "I give it up; I don't see anything funny in it."

† "The standard candle, which ought to give a light of 4π, is about as absurd as the horse-power. The candle and the horse are about equally obsolete, and the candle is about as likely to give a candle-power—or 4π units of British light—as a horse to give a horse-power. The horse has one advantage over the candle: he is not inextricably mixed up with the 4π controversy, and well-meaning people do not try to rationalize him as a unit."—Mr. J. Swinburne's Presidential Address, *Journal Inst. Elec. Engrs.*, vol. xxxii. p. 39.

be described. These involve the consideration of 4π and the solid angle; we have to hamper ourselves with dimensions, but get rid of them in the result. Mean spherical candle-power, so far as candle-power is concerned, is nothing more than the average candle-power in all directions, and has nothing to do with flux.

The quantity 4π, multiplied by the luminous intensity or candle-power, has been called by M. Blondel a lumen. It may perhaps deserve a name. Meanwhile "mean-spherical-candle-power" must serve for both. The flame of a candle pours out energy, partly luminous, and partly non-luminous. The total light may be measured as a rate of emission of luminous energy. This is an instantaneous value. The product of this by time would give a quantity in terms of energy.

This product of candle-power into solid angle has an application in connexion with distribution of illumination, and another in connexion with the diffused reflecting power of a dead or matt surface, or with the analogous case of the transmission of light through opal glass or paper. The elementary geometry of this will be dealt with in a later section.

Brightness or Intrinsic Brilliancy.

There is no essential difference between brightness and illumination. Brightness or intrinsic brilliancy is generally applied to a surface which emits light, and illumination or luminosity to one on which light is received. The hole in the screen which Methven placed in front of his Argand burner, burning non-carburetted gas, was 0·233 square inch in area. This gave a standard of 2 candle-power. The brightness of this part of the flame was, therefore, 8·6 candle-power per square inch. The projected area of the flame of a standard candle, as viewed horizontally, is about 0·56 square inch. The brightness is therefore 1·8 candle-power per square inch. This brief account of the quantity will suffice here, and other aspects of it will be discussed in a later section.

Quantity of Light and Quantity of Illumination.

M. Blondel has suggested the lumen-hour as a unit on which commercial contracts for lighting may be based, but there seems to be no pressing need for such a unit. A foot-candle-hour is a much more useful unit. The result in foot-candles is what is wanted, the mean spherical candle-power-hour is only a means to an end. At the International Photographic Congress at Brussels in 1891 the "bougie-metre-second" was adopted. Every photographer consciously or unconsciously uses a "time-illumination" unit, for this quantity is nothing more or less than what he calls "exposure." An illumination of 5 foot-candle-seconds gives a sensitive shade of grey on ordinary slow bromide paper.

Distribution of Illumination on a Plane.

The case of the illumination of a horizontal plane by a light radiating uniformly in all directions is the most simple, and at the same time the most useful and common problem for out-door work. The candle-power may be assumed to be constant, and need not enter into the matter. It will be taken as unity. The height of the lamp above the ground is also constant, and will also be taken as unity. The illumination at any point on the plane varies inversely as the square of the distance from the light; that is, it varies inversely as the square of the slant distance of the lamp. It also varies as the cosine of the angle of incidence. In Fig. 8 it will be seen

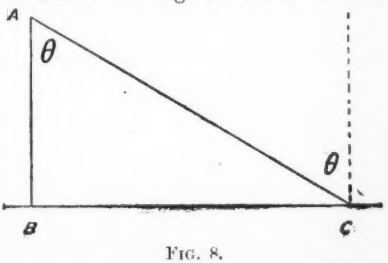


Fig. 8.

that the illumination at C varies inversely as the square of AC since AC is the slant distance, and it also varies

as AC, because, when AB is unity, the inverse ratio of AC is the cosine. The illumination will therefore be inversely as $AC \times AC^2$, or as the cube of the cosine of the angle of incidence. It is not necessary to measure or to know θ, the angle of incidence. The illumination at the point C being inversely proportional to the cube of AC, and proportional to the height AB and to the candle-power of the light

$$i = \frac{AB \times c.p.}{AC^3}$$

where i is the illumination in foot-candles, and $c.p.$ the candle-power, and AB and AC distances measured in feet.

The curve in Fig. 9 represents the illumination at any point on the horizontal plane by the height of the ordinate at that point, the maximum being unity. The value of the cubed cosine being of great importance in all such cases, and being somewhat tedious to calculate, the following tables, abridged from those given in the original paper,* together with the tangent of the angles of incidence, are given for convenience in plotting such curves as Fig. 9. The tangent of the angle of incidence θ is the ratio of BC to AB (Fig. 8), and AB being considered here as unity, the tangent is the length BC.

The eye, after a little experience, is better able to judge degrees of illumination than of candle-power. Difficulties introduced by brightness or intrinsic brilliance are absent, but small differences can only be estimated with the help of photometric apparatus. The small and gradual changes of illumination shown so clearly on Fig. 9 could not be estimated or even detected by the eye. Weber has shown that the intensity of visual sensation is not directly proportional to the luminous stimulus. Illuminations, or, indeed, any other sensations cannot be quantitatively compared; but quality can only be estimated, and that very roughly, compared with other measurements.*

But gradual changes of illumination, imperceptible though they may be, have an actual existence; and the tables given here, originally to four figures, and now reduced to three, need not be regarded as aiming at extreme accuracy, but are provided as a basis for other calculations. Illumination on a horizontal plane decreases so rapidly with the distance, that at an angle of incidence of about 37°, or at a horizontal distance of three-quarters the height of the lamp from the ground, it falls off to one-half, at about 45° to one-third, and at 62°, or at a horizontal distance of nearly twice the height of the lamp above the ground, one-tenth of the maximum.

* *Proc.* Inst. Civil Engrs., vol. cx. p. 120.

* Weber's law has been expressed thus: "The smallest change in the magnitude of a stimulus which we can appreciate through a change in our sensation always bears the same proportion to the whole magnitude of the stimulus.....This law holds good within certain limits only: it fails when the stimulus is either above or below a certain range of intensity."—Michael Foster, 'Text-Book of Physiology,' fifth ed., part iv. p. 1211.

Weber discovered this principle in certain special cases; Fechner proves that it holds for all kinds of sensations. The proportion for light sensation is about 1/100, for muscle (*i.e.*, judging weights) about 1/17, and for pressure and sound about 1/3. See Wundt's 'Human and Animal Psychology,' Lecture II. The law may also be expressed in a mathematical form.

A distinction must be observed between the degree of accuracy with which a sensation may be estimated and the smallest perceptible difference between two sensations. Those who are not accustomed to estimating weights would have a difficulty in guessing which of two weights, one a pound and the other a pound and a quarter, was the pound, though, of course, one would appear distinctly heavier than the other. This corresponds with the difficulty of estimating the candle-power of a lamp by looking at it.

Fechner showed that most people can just perceive that a weight of 17 ounces is heavier than a weight of 16 ounces; but the difference between 30 and 31 ounces cannot be detected by muscular sensation; the heavier weight would have to be increased to about 32 ounces. This corresponds to the judgment in photometry, which Fechner puts at $\frac{1}{10}$.

TABLE I.—ROUND NUMBERS OF $\text{Cos}^3\theta$.

$\text{Cos}^3\theta$	$\text{Cos}\,\theta$	θ	$\text{Tan}\,\theta$	$\text{Cos}^3\theta$	$\text{Cos}\,\theta$	θ	$\text{Tan}\,\theta$
		° ′				° ′	
0·995	0·998	3 20	0·058	0·360	0·711	44 39	0·988
0·990	0·997	4 43	0·083	0·340	0·698	45 44	1·026
0·980	0·993	6 38	0·116	0·320	0·684	46 51	1 067
0·960	0·987	9 25	0·166	0·300	0·669	47 59	1·110
0·940	0·980	11 35	0·206	0·280	0·654	49 8	1·156
0·920	0·973	13 27	0 239	0·260	0·638	50 20	1·206
0·900	0·966	15 5	0·270	0·240	0·621	51 35	1·261
0·880	0·958	16 36	0·298	0·220	0·604	52 52	1·321
0·860	0·951	18 1	0·325	0·200	0·585	54 13	1·387
0·840	0·944	19 21	0·351	0·190	0·575	54 54	1·423
0·820	0·936	20 36	0·376	0·180	0·565	55 37	1·461
0·800	0·928	21 50	0·401	0·170	0·554	56 21	1·502
0·780	0·921	23 0	0·425	0·160	0·543	57 7	1·547
0·760	0·913	24 8	0 448	0·150	0·531	57 54	1·594
0·740	0·905	25 15	0·472	0·140	0·519	58 43	1·646
0·720	0·896	26 20	0·495	0·130	0·507	59 34	1·702
0·700	0·888	24 23	0·518	0·120	0·493	60 27	1·764
0·680	0·879	28 26	0·542	0·110	0·479	61 22	1·832
0·660	0·871	29 28	0·565	0·100	0·464	62 20	1·907
0·640	0·862	30 29	0·589	0·090	0·448	63 23	1·995
0·620	0·853	31 30	0·613	0·080	0·431	64 28	2·093
0·600	0·843	32 30	0·637	0·070	0·412	65 40	2·211
0·580	0·834	33 29	0·662	0·060	0 392	66 57	2·350
0·560	0·824	34 29	0·687	0·050	0·368	68 23	2·524
0·540	0·814	35 29	0·713	0·040	0·342	70 0	2·747
0·520	0·804	36 29	0·740	0·030	0·311	71 54	3·059
0·500	0·794	37 28	0·766	0·020	0·271	74 15	3·546
0·480	0·783	38 28	0·795	0·010	0·215	77 34	4·536
0·460	0·772	39 28	0·823	0·008	0·200	78 27	4·893
0·440	0·761	40 29	0·854	0·005	0·171	80 9	5·759
0·420	0·749	41 30	0·885	0·002	0·126	82 46	7·880
0·400	0·737	42 32	0·917	0·001	0·100	84 15	9·931
0·380	0·724	43 35	0·952				

TABLE II.—ROUND NUMBERS OF θ.

θ	$\text{Cos}^3\theta$	θ	$\text{Cos}^3\theta$
2	0·998	40	0·449
4	0·993	42	0·410
5	0·989	44	0·372
6	0·984	45	0·354
8	0 971	46	0·325
10	0·955	48	0·300
12	0·936	50	0·266
14	0·914	52	0·233
15	0·901	54	0·203
16	0·888	55	0·189
18	0·860	56	0·175
20	0.827	58	0·149
22	0·797	60	0·125
24	0·761	62	0·1035
25	0·744	64	0·0843
26	0·726	65	0 0755
28	0·688	66	0·0673
30	0·650	68	0·0526
32	0·610	70	0·0400
34	0·570	72	0·0295
35	0·550	75	0·0173
36	0·530	80	0·0052
38	0·489	85	0·00066

TABLE III.—COMBINATIONS APPROXIMATELY EQUAL TO ONE FOOT-CANDLE.

Candle-power.	Ft.	In.	Candle-power.	Ft.	In.
1	1	0	64	8	0
4	2	0	100	10	0
8	2	10	144	12	0
9	3	0	200	14	2
16	4	0	400	20	0
20	4	6	600	24	6
30	5	6	1,000	31	8
50	7	1	1,600	40	0

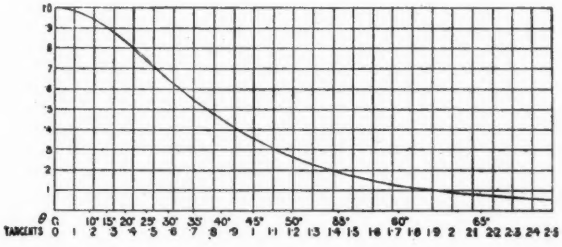


FIG. 9.

(To be continued.)

The Tungsten Lamp.

By Prof. Dr. A. Grau.

Modern methods of producing light tend towards an ever-increasing temperature of incandescence on the part of the light-giving body. Some exact experiments, in recent years, have shown that the total luminosity of such a body is proportional to the twelfth power of the absolute temperature (*i.e.*, degrees Centigrade + 273).

If, therefore, the temperature of a body yielding 10 c.-p. at 1,800 degrees abs. be increased to 2,000 degrees abs., the light yielded at the latter temperature becomes $\left(\frac{2000}{1800}\right)^{12} = 3{\cdot}54$ times as great as before, and the body now yields 35·4 c.-p.; thus an increase in temperature of 11 per cent. has produced an increase in the yield of light of 254 per cent.

The carbon filament incandescent lamp consumes about 3–3·5 watts per c.-p. (Hefner), at an absolute temperature of 1,800 degrees abs., but attempts to increase the efficiency by exceeding this value are defeated by the tendency of the carbon to form a light-absorbing deposit on the inside of the glass bulb. This tendency to increased volatilization on the part of carbon at light temperatures makes it difficult to very appreciably increase the efficiency of the carbon filament lamp. Such efforts only result in increased efficiency at the expense of the durability of the filament. Endeavours were therefore made to secure a refractory substance, which could withstand higher temperatures than carbon without deterioration, and so would successfully work at a smaller consumption than 3 watts per H.K.

Such materials are exemplified in the Nernst, Tantalum, and Osmium lamps, in which 1·5 watt per H.K. were obtained.

But the work of the last few years has shown that the metal Tungsten can bear higher temperatures than the materials mentioned above without either melting or depositing as a film on the bulb of the lamp. As a result of these researches a Tungsten lamp consuming 1 watt per H.K. can now be regarded as an accomplished fact.

Three distinct processes for the manufacture of Tungsten filaments are in use:—

1. The "substitution-process" of Just and Hanaman.
2. The "paste-process" of the Auer-Osmium (Westinghouse) Co.
3. The "colloidal-process" of Kuzel.

In the substitution process the carbon filament is gradually furnished with a metallic deposit of Tungsten. In the paste-process very finely powdered Tungsten is mixed with some binding material into a paste, from which filaments can be squirted. In the colloidal-process very finely divided Tungsten in a colloidal condition is prepared, and filaments can be worked up from this without the aid of an added binding material.

The author has carried out some investigations with the object of ascertaining whether the greater efficiency

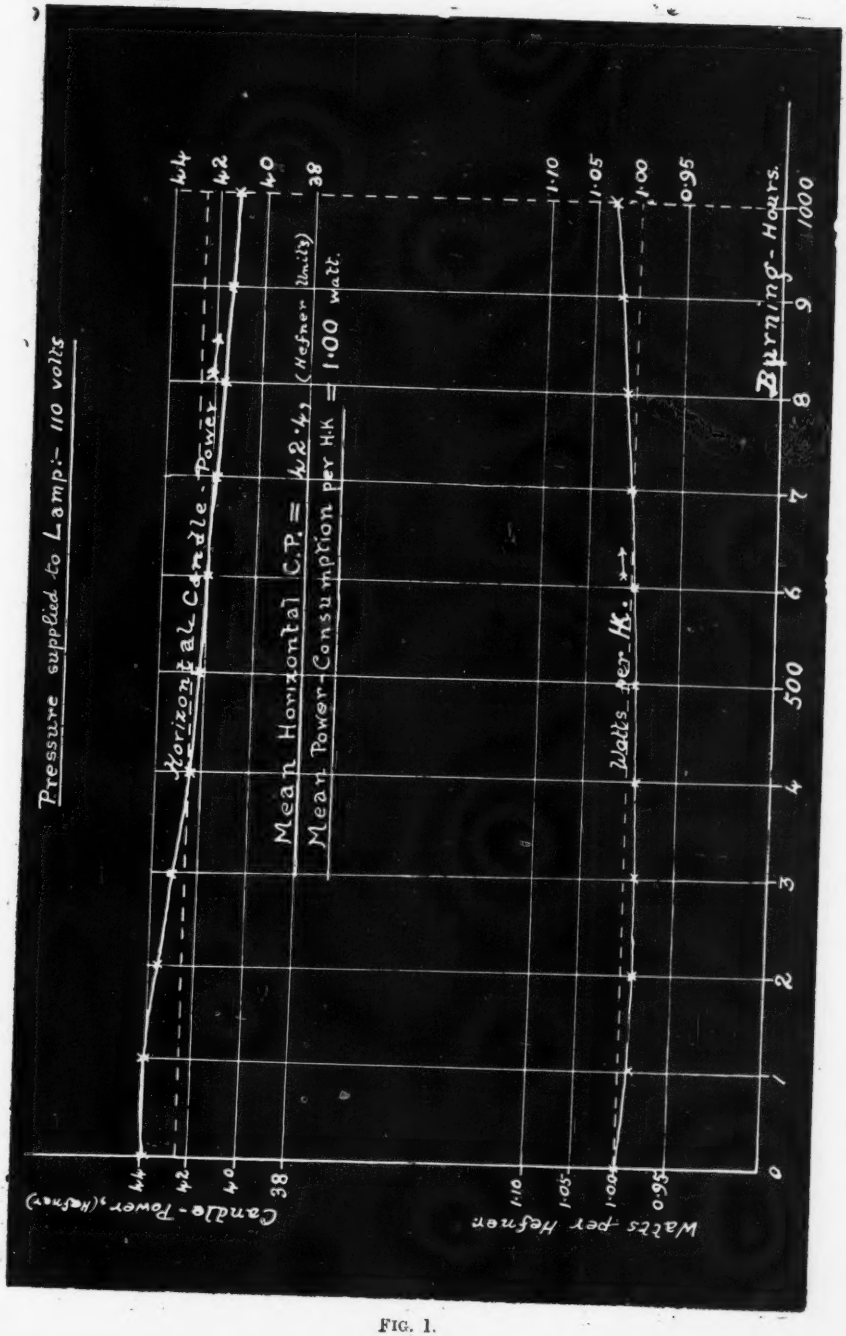

Pressure supplied to Lamp:- 110 volts
Horizontal Candle-Power
Mean Horizontal C.P. = 42·4, (Hefner Unit)
Mean Power-Consumption per H.K. = 1·00 watt.
Candle-Power, (Hefner)
Watts per Hefner
Watts per HK.
Burning-Hours.
44
42
40
38
1·10
1·05
1·00
0·95
0
1
2
3
4
500
6
7
8
9
1000

FIG. 1.

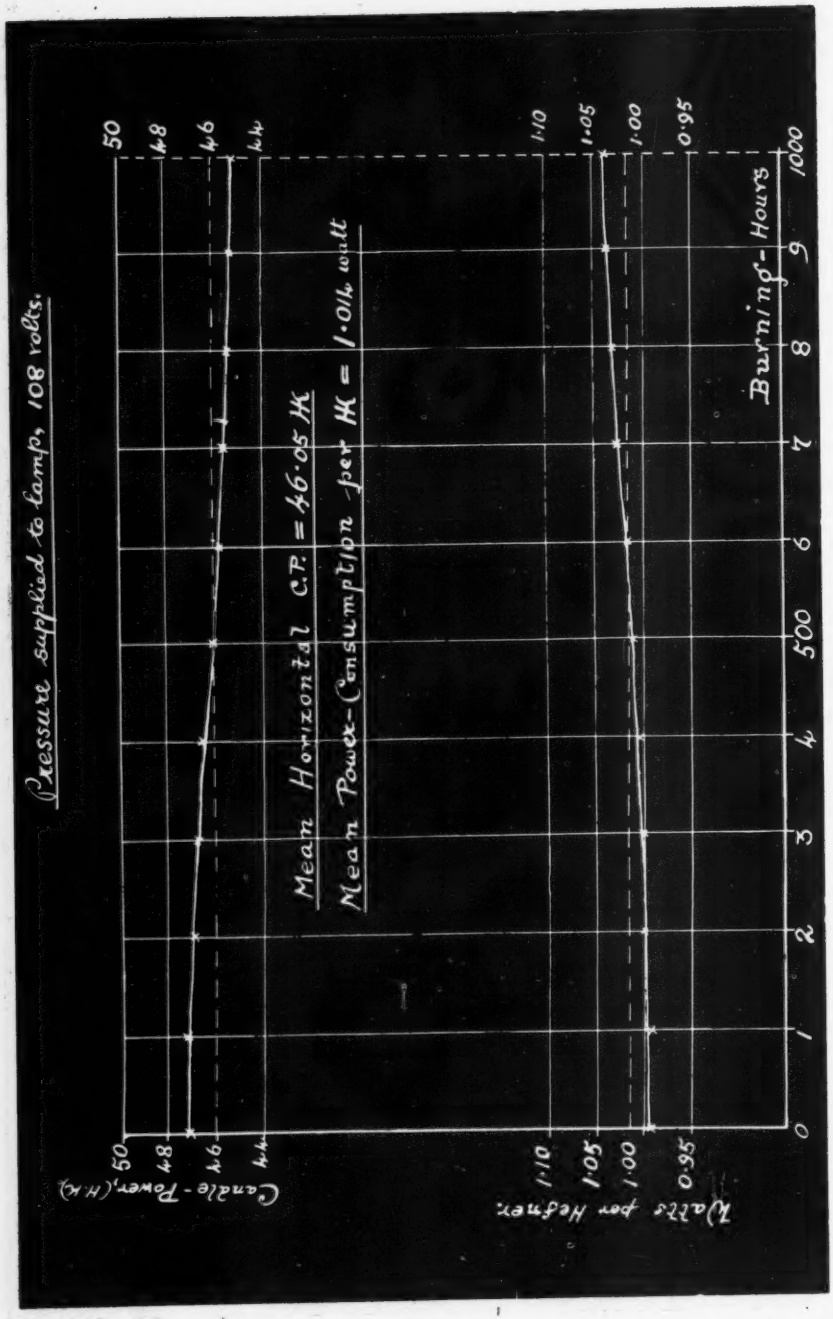

Pressure supplied to lamp, 108 volts.
Mean Horizontal C.P. = 46·05 HK
Mean Power-Consumption per HK = 1·014 watt
Candle-Power, (H.K.)
Watts per Hefner
Burning-Hours
50
48
46
44
1·10
1·05
1·00
0·95
0
1
2
3
4
500
6
7
8
9
1000

FIG. 2.

of the Tungsten, as compared with the carbon filament lamp, is to be ascribed to its higher temperature. In these experiments a special optical method was employed.*

The temperature of the carbon filament lamp (taking 3 watts per H.K.) was found, in this way, to approach 1,660 degrees Centigrade, while that of the Tungsten-lamp, burning at 1 watt per H.K., was in the neighbourhood of 1,850 degrees Centigrade.

The empirical law, connecting the temperature and the integral brightness of an incandescent body, has been given by Lummer and Kurlbaum as :—

$$\frac{H_1}{H_2} = \left(\frac{T_1}{T_2}\right)^{\alpha}$$

where H_1, H_2, denote the brightness corresponding to the absolute temperatures T_1, T_2, respectively, and α is a coefficient which approaches the value 12 for temperatures over 1,900 degrees Centigrade.

For the same energy-consumption the candle-power of a Tungsten lamp, at a temperature of 1,850 degrees Centigrade (*i.e.*, 1,850 + 273 = 2,123 degrees absolute), was found to be three times as great at that of a carbon filament lamp at a temperature of 1,660 degrees Centigrade (*i.e.*, 1,660 + 273 = 1,933 degrees absolute).

If, therefore, the greater output of light from the Tungsten lamp is solely to be ascribed to its higher temperature, we ought to find that :—

$$\left(\frac{2123}{1993}\right)^{12} = \frac{H_1}{H_2} = 3.$$

Actually the above expression works out to 3·07.

This, therefore, seems to show that the higher temperature of the incandescent Tungsten lamp *is* the cause of its greater efficiency.

What has hitherto been a disadvantage of Tungsten lamps was the fact that, owing to the softness of the glowing filament, they could only be burned in a vertical position. More recently, however, the filaments have been provided with suitable support, and can now be burned in any position that is desired.

While the efficiency of the carbon incandescent lamp rapidly diminishes with life, that of the Tungsten lamps only changes comparatively slightly.

The watts per c.-p. diminish during the first portion of the life of a lamp and subsequently slowly increase. The course of the life of an average Tungsten lamp is shown in Figs. 1 and 2, both of which represent the mean of a large number of results.

Lamps both for 110 volts and 220 volts are now available, yielding 25 and 45 c.-p. respectively. The Tungsten lamp is an excellent illustration of the recent progress which has been made in the manufacture of incandescent glow-lamps.

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* "Über Temperatur und Lichtemission von Kohle, Osmium, und Wolfram." *Zeitsch. für Elektrotechnik u. Maschinenbau*, April 14, 1907, p. 295.—The optical method of measuring the temperature of filaments described in the above paper is essentially as follows :—

A piece of iridium foil was brought to incandescence by the passage of an electric current, and its temperature was estimated by means of a Wanner pyrometer, previously calibrated by observation of a radiating "black body." This enabled the author to determine the "black body" temperature of the iridium (*i.e.*, that temperature which a black body must have in order to emit the same radiation as the iridium foil).

The glow lamp-filament to be investigated was then observed through a telescopic tube with the incandescent foil as a background, and the current through the filament was adjusted until it became indistinguishable from the bright background. When this occurred it was assumed that the temperature of the filament was the same as that of the foil, and therefore known.

At the higher temperatures observations were made through a deep red glass which rendered the light monochromatic

The Preservation of the Eyesight in Children.

By Hubert E. J. Biss, M.A. M.D.(Cantab.) D.P.H.

The Education (Administrative Provisions) Act passed last year enforces on education authorities throughout the country the duty of providing machinery for the medical inspection of elementary school children under their care. The potentialities for good which lie in this measure are great, almost overwhelming—that is, if the Act be administered in a broad and generous spirit. At the moment one cannot but be impressed by the fact that authorities generally, while rendering homage to the principle of the measure, seem to wish to get out of the practical responsibilities imposed upon them at the least possible cost. This is not the place to enter into local politics, but it is obvious that cheap inspection is likely to be perfunctory inspection, or if not perfunctory, at least not highly-skilled inspection. If the work is to fall into the hands of callow lads, or bread-and-butter young ladies, fresh from hospital, medical inspection is likely to become something very like a failure, both administratively and medically. Sympathetic knowledge of children and seasoned experience of parents are essential attributes for the work, for the inspector has first of all to entice youngsters to disclose their shortcomings, and then to persuade the parents that preventive or remedial measures are necessary.

In nothing will these qualities be more needed than in the discovery of defective eyesight and the teaching of its significance. The amount of ocular mischief in town-bred children is immense, and so little is it recognized that one is apt to be looked upon as a crank, a faddist, or an alarmist, for insisting on the elementary precautions that sense and science alike show to be necessary, if education is not permanently to damage thousands of the youngsters who are now hustled to school by crusty parents and conscientious attendance-officers. Nor is it only the children of the poor that are threatened, and not infrequently engulfed, by these dangers. It is paradoxical, but no less true, that the qualifications for teaching children and the capacity for understanding them are far more diligently inquired into in the case of most elementary school teachers than in that of those who instruct the young sprigs of the "nobility and gentry." A candidate for a mastership in an upper-class school is considered sufficiently accomplished if he has pursued a mute, inglorious career at one of the universities, and his claim is rendered undeniable if he has played cricket in his college eleven and been "tried for the 'Varsity." That these healthy young barbarians, as Matthew Arnold taught us to call them, have no knowledge of teaching may be a matter for regret; that they have no acquaintance with the physiology of the child is something approaching disaster. How can the pedagogue barbarian be expected to think that a wretched little astigmatic, who can only see half of his book at a time, is anything but a "stupid young ass"? Or what wonder is it if he add two or three dioptres to the myopia of all the short-sighted boys in his class by making them gaze at

the blackboard in impossible cross-lights, or write out five hundred lines because their nightwork is constantly unsatisfactory? Just in proportion as the eye is of higher educative value than all the other senses, so is it worth the more careful preservation, and if parents and the custodians of the young are not instructed in the dangers of eye-strain and its prevention, their wards are likely to be cut off from the most valuable channel of knowledge.

The eye is endowed with capabilities for conveying information to the brain which makes all other sources pale into insignificance. The extent covered by the field of vision is bounded only by the horizon; the rapidity with which knowledge is conveyed by the eye is as close an approximation to instantaneousness as we are acquainted with in nature; and the variety of qualities such as form, size, colour, number, and texture, which it can appreciate in an object, has made the verb "to see" synonymous with the verb "to comprehend" in every civilized language. Milton deplored the loss of his sight at least as much from the educative as from the social standpoint, for in his address of 'Light,' after bewailing what his affliction deprived him of in æsthetic joy, he cries,—

> "and for the book of knowledge fair
> Presented with a universal blank
> Of Nature's works, to me expunged and rased,
> *And wisdom at one entrance quite shut out.*"

That that one entrance should by all human effort be preserved is the birthright of every child.

It is only of recent years that it has been possible to obtain definite facts as to the eyesight of the rising generation. The credit of having instituted systematic inquiry belongs to the late London School Board, which in the year 1899 passed a resolution that teachers should be requested to test the eyesight of children by means of certain testing-cards with which they were supplied, and to record the results. The figures obtained were doubtless somewhat crude, as the work was new to the teachers, no checking or supervision by medical men was carried out, and the tests were somewhat hurriedly run through in the foggy month of December. Still, not only as a valuable departure in school hygiene, but as actual demonstrative evidence of the prevalence of eye-defects, the results were little short of epoch-making. To make the figures obtained intelligible to those unacquainted with the usual methods of expressing the results of vision-tests, it may be well to explain that the standard test-type is constructed to be read at a distance of 6 metres. If the examinee cannot read it at that distance he is shown types which a normal eye can read at 9 metres; if he cannot read those, he is taken on successively to such as can ordinarily be read at 12, 18, 24, 36, and 60 metres. The smallest type the examinee can read is taken as the measure of his vision, and the result is expressed in a fraction, the numerator of which states the distance at which he was standing, namely, 6 metres in the usual way, and the denominator, the distance at which the type which he actually read can be read by a normal eye. Thus normal vision is expressed by the fraction $\frac{6}{6}$, which signifies that the type which should be read at 6 metres has actually been read at 6 metres. Less good is $\frac{6}{9}$, which indicates that the examinee could at 6 metres only read type which should have been read at 9 metres, and so on. In the first examinations under the School Board $\frac{6}{6}$ and $\frac{6}{9}$ were classified as "good vision"—though $\frac{6}{9}$ is already distinctly below par—and $\frac{6}{12}$ or less as "defective vision."

And now as to results. The number of children examined was 338,920. Of these, 259,523, or 76·6 per cent., were returned as having "good vision," and no less than 79,167, or 23·3 per cent. as having "defective vision." In other words, a quarter of this enormous number of children suffered—unsuspected—from marked eye-defects, and of them 2,675 at 6 metres could only see what they should have read at 60 metres, and 230 were unable to read any test type at all! With regard to districts it is interesting to observe that the highest percentage of defects was found in the City, where only

56·6 per cent. of children—barely more than half—had good vision, the other districts below the average being Westminster, Hackney, Tower Hamlets, Finsbury, and Southwark. These are all thickly populated neighbourhoods, and as bearing out the relationship of congestion to visual deficiency, it is noticeable that in Greenwich, Lambeth, Chelsea, and Marylebone, where homes are less densely packed and open spaces more ample and numerous, the eyesight was above the average. These observations lend further illustration to the principle that where small demand is made on the eye for distant vision, the acuity of sight is proportionately less.

Dr. Kerr, who had been in practice as an ophthalmic surgeon, was appointed Medical Officer to the School Board shortly before that body was disintegrated, and was retained in the same capacity, to the great advantage of the London child, by the Education Committee of the London County Council. The work initiated before his advent met with his warm co-operation on taking office, and under his advice the machinery for examination was elaborated and strengthened. Ophthalmic surgeons were appointed to check the results of the teachers' testing, and various further points were brought under investigation. Vision was now classified as "good" when $\frac{6}{6}$, "fair" when $\frac{6}{9}$ or $\frac{6}{12}$, and "bad" when $\frac{6}{18}$ or less. The effect of defective vision on school progress was examined into, and the effect upon eyesight of crowded and open areas more thoroughly investigated. As the result of the first year's work under the new conditions, five important facts were brought out:—

1. That among children with defective sight the proportion below the average educational standard of their class, at every age from eight years to twelve, is considerably higher than that of those above the standard.

2. That visual acuity increases with each year of school life.

3. That a constant proportion of 10 per cent. of children have "bad" vision throughout school-life.

4. That the greater part of the defective vision is due to slight defects which give imperfect but fair vision, due probably to mental and ocular conditions, and of the greatest importance educationally in the first half of school-life.

5. Finally, that very bad vision ($\frac{6}{36}$ or worse) is met with in a proportion increasing regularly from 1·5 per cent. in the lowest standard to 3·5 per cent. in the highest.

One paragraph of the report is so important that it deserves quotation verbatim. "School effects," wrote Dr. Kerr, "from fine work and poor illumination are more likely to show themselves in general nerve strain and unhealthy neurotic or nutritional conditions than in very defective visual acuity during school-life. The real harm of defective vision and of school-work not adapted to the visual capacity of the young lies in the strain thrown on the developing nervous system."

Further experience has only served to strengthen these conclusions, and the work of weeding out the visually unfit and instilling scientific notions of what are proper conditions of illumination, and what class of work is adapted for children at various ages, has progressed steadily. The last year for which full returns are available is 1907, and the large number of children examined, over 400,000, the accuracy of the work—all the results being checked by ophthalmic surgeons—and the effect of extended experience as to what constitutes dangerous defect in vision in children, all combine to lend them permanent interest. Of the total examinees, 409,944 in number, the teachers returned 44,139 (10·7 per cent.) as defective for school purposes. This number was reduced on expert examination to 32,149 (7·8 per cent.), and, finally, 28,492 were given cards urging that surgical advice should be sought. A striking fact about these figures is that they include non-provided as well as provided schools, and though the former as a whole contain a rather better class of child, the visual defects were markedly higher in them than in the provided schools. One cannot resist the reflection that the bad

hygienic conditions, especially as to the lighting of class-rooms, prevailing in many non-provided schools may be largely responsible for this disparity. There is not room here to discuss more fully the question of the prevalence and significance of these eye-defects, but, lest it should be thought that the London child is gifted with exceptionally bad vision, it is instructive to note that in the investigations carried out among the school children of Aberdeen and Edinburgh under the auspices of the Royal Commission on Physical Training (Scotland), it was found that in Edinburgh the percentage of normal vision, as fully tested by refraction, was only 45·33, and that in Aberdeen was even less, namely, 43·8! It is not to be presumed that all the defective children these figures connote were in need of immediate treatment; but the Commissioners wrote with regard to those in Aberdeen: "The proportion of children requiring correction by spectacles for errors of refraction was slightly under one-fourth of the whole of the children examined"!

Before turning to the preventive measures necessary to obviate the aggravation of visual defects, attention should be drawn to the fact that in the child the eye normally is shallower from before backward than in the adult. The consequence of this is that the amount of accommodation which in an adult would focus the image of the object looked at on the retina, would in the child still throw it behind that structure, and that therefore a child needs to make a stronger effort at accommodation to achieve the same result as a grown-up person. Another difference is that the lens of a child's eye is normally more convex than in the adult, and therefore, whereas the latter relaxes his accommodation for distant vision, in the child a distinct effort is necessary to accomplish the same object. Now eye adjustments, especially those for near vision, are muscular actions. The reading of a book involves no less than three distinct efforts, namely, an effort by the muscles attached to the eyeballs to bring the eyes towards the middle line, so that the visual axes may converge on the print; an effort by the ciliary muscle to adjust the lens to an appropriate condition of convexity; and an effort by the circular muscles of the iris to make the pupil contract and shut out divergent rays of light. Now not only have these muscular efforts to be made, but they have to be kept up all the time that reading is going on, and as all muscles weary under strain, and as the strain in the case of the child is greater than in an adult, it is clear that this fatigue is a very real and trying factor. As the eye develops normally the visual acuity increases. It has already been pointed out in Dr. Kerr's figures that the vision in the various standards improves with age. But if by muscular strain the elastic eyeball of the child be unduly dragged upon, any existing defective condition may be greatly increased, and in any case the mental and nervous symptoms produced not only retard educational progress, but actually endanger the general health.

Though these questions may appear to many to be of more or less academic interest, to all associated with children in every class of society, they "palpitate with actuality," as the French have it. No parent, especially if he be a town-dweller, can afford to let his child run the risks involved to health, progress, and eyesight, which negligence of the hygiene of the eye involved. Some of the necessary elementary measures for avoiding eye-strain may be usefully mentioned. First and foremost is the question of illumination, natural and artificial. Lighting should not be too stinted, nor too abundant, nor wrongly directed. In the schoolroom or nursery the window-area should be at least one-sixth of the floor-space, and one-fourth is better. The windows should reach nearly to the ceiling, and should descend so near the floor that the minimum of shadow is obtained beneath them; moreover, they should be placed as close together as structural stability allows, so that there may be no shadow between them. It is far better that light should be admitted on one side only of the room; in the case of the school this should be the left. The end walls should be blank,

covered by a pale neutral tinted paper. Top-lights are rightly forbidden by the Education Code. If sufficient illumination cannot be obtained by the windows on the left, light must be admitted from the right, but it must be distinctly understood that such a supply is supplementary, and the amount of window-space strictly limited by actual needs. Nothing is more puzzling to the eyes than a cross-light. To prevent too great an access of light on sunny days, blinds should be provided to cover the whole window area, and they should be made of green holland or other dark material. For artificial illumination electric lighting is best, especially a high candle-power lamp in a frosted globe. One type of lamp is so excellent that out of gratitude I am almost tempted to mention it, but as my subject is scientific and not commercial, I refrain. No doubt there are plenty as good.

Next to illumination comes the question of position. The near point at which a child should work with its eyes is a distance of twelve inches; at any rate, not a fraction under ten. Any child who cannot read, write, and sew comfortably at this distance is either possessed of defective vision, or is forming habits fatal to ocular health. The body should be upright, supported in the middle of the back, with the thighs at right angles to the body, and the knees at right angles to the thighs; the feet should rest flat on the floor, and the desk or table should admit of this attitude being easily maintained. To prevent the head drooping the surface containing the work should be adjustable to an angle of from 15 degrees to 20 degrees for writing, and from 30 degrees to 40 degrees for reading. In the case of reading it is most important that no printed books should be given to young children under five, and picture-books should only contain bold objects unembellished with fine detail. School-books are much better than they were, but there is still much room for improvement. Children between nine and twelve years of age should be allowed no print smaller than *Pica*.

(This shows the size of Pica.)

Children below that age should have their books printed in *Double Pica*,

(This shows the size of Double Pica.)

or *Great Primer*,

(This shows the size of Great Primer).

The margins should be wide, the lines and letters well leaded out, and all type used should be fresh and sharply cut.

Writing is the most trying of all exercises, and it should never be long continued. Unlined paper and ink are the materials of choice, and the small ruled squares in which the letters have each to be formed separately should never be permitted. All paper for reading or writing should be unglazed, and the so-called vertical script is worthy of hygienic commendation on account of the lack of temptation it offers to the formation of faulty attitudes. For girls there remains the crucial question of sewing, and it must regretfully be admitted that this admirable domestic art is one beset with danger to the youngster's eye. For girls under five it should be absolutely forbidden. After that age a darning needle and coarse yarn may be used if the yarn is of a dark colour, and the material on which it is worked is of a pale shade, or vice versâ. But even this modest accomplishment must be carefully supervised, and if the child be found to bring the work close to the eyes, needle and yarn should be put away for a year or two. Fine needles, fine thread, and fine work are bad for anybody, and they certainly should not be used by girls till they are in their teens. Perhaps the most pernicious sewing-work is the very useful

one of "patching," when the object of the seamstress is to make her repairing work as neat and little obtrusive as possible. It is the veriest tempting of Providence to set children to it.

In view of the well-ascertained dwarfing of visual acuity which town life conduces to, it is hardly necessary to say that the open country is the ideal entourage for a child, more especially such as have known defects of vision. To give the eye free play as far as the horizon, with the minimum amount of near work and the least possible confinement to houses and streets, is the natural and rational method of preserving the eyesight. Apart from the direct benefit produced to the general health of children by bringing them up in the country, the value of rural life in sparing the eyes from undue fatigue, and thus sparing much mental and nervous irritability, is very real indeed, and constitutes not the least of the benefits which a back-to-the-land policy would bring about. I shall hardly be deemed guilty of exaggeration by those in a position to judge if I say that much of the change the national character has undergone during the last century is due to the changed ocular conditions under which children are brought up. It is the duty of everyone at least to see that these conditions operate as little harshly as may be.

The First Municipal, Building, and Public Health Exhibition.

THE exhibition described under the above title is the first of its kind, and is to be held at the Agricultural Hall from the 1st to the 12th of May of the present year. We note that among the various subjects to be dealt with the questions of house and street lighting are to receive attention. The interest of these subjects to the municipal engineer, the architect, and others who are concerned with the exhibition referred to, is undeniable.

The opportunity afforded of bringing the need of good illumination prominently before the notice of those interested in municipal matters seems to us an exceptionally good one. We hope that full advantage will be taken of the facilities offered by the organizers of the exhibition, and that arrangements will be made to secure the exhibit of the most recent developments of different methods of lighting, and the most modern methods of measuring illumination.

The Production and Utilization of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 105.)

[The subsequent articles in this series (following the previous introduction), the first of which we reproduce in this month's issue, will deal with the following subjects:—

1. A brief history of lighting.
2. The laws and measurement of radiation.
3. Optical measurements.
4. Luminous efficiency and the mechanical equivalent of light.

It has been found necessary, in order to avoid repetition, to slightly abbreviate the first of this series.]

A BRIEF HISTORY OF ARTIFICIAL LIGHTING.

Before entering upon the consideration of the details of modern methods of lighting, and the underlying theory, some attention may profitably be devoted to the evolution of artificial lighting to its present stage; from which we may see what fields have been already explored, and the extent to which each has been developed.

The origin of artificial lighting is, of course, lost in obscurity, as it dates from the production of fire, which took place long before historic times.

Athenæus (fourth century B.C.) speaks of lamps as not being of ancient origin, but during that century they appear to have been in fairly general use for religious ceremonies. The Greek lamp, or λυχνος, generally consisted of a terra cotta reservoir with handle at one end, and a short spout at the other, into which some threads, forming a wick, were introduced. The lamp was filled with animal oil, through a larger central aperture. In some cases, a ring of wick apertures surrounded the central hole. The spread of Greek civilization caused the introduction of lamps into Rome, Egypt, Persia, Medea, and Assyria; and little advance seems to have been made until comparatively recent times.

Street lighting appears to have been first attempted in Paris, about 1558, by means of pitch or resin soaked torches, but was very unsatisfactory.

During the eighteenth century some investigations were made which led to the rapid advance in artificial lighting in the early part of the last century. Dr. Hales found that when pit coal was heated in closed vessels, nearly one-third of it became volatilized in the form of an inflammable vapour. Dr. J. Clayton in 1739 distilled Newcastle coal, obtaining an aqueous fluid, a black oil, and an inflammable gas which he stored in bladders and lit. In 1767, the Bishop of Llandaff found that coal gas preserved its inflammable character after passing through water. But it is to William Murdoch, who in 1792 commenced experimenting on a larger scale, that we owe the first realization and application of gas lighting. He employed iron retorts, and pipes of tinned iron or copper, by which the gas was carried for distances of as much as seventy feet. He also used gas bags for storage, and experimented on nozzles of different shapes as burners. Other work intervened, and stopped his experiments for a time, but in 1797, at Old Cumnock, in Ayrshire, he repeated his experiments; and in the following year he constructed a gas-making plant at Bolton & Watts foundry in Soho, in which he distilled, washed, and purified the gas.

The Gas Light and Coke Co. was formed in 1810, and the first public use of gas was in lighting Westminster Bridge in 1813.

Modern methods of artificial lighting therefore date, like most other practical applications of science, from the commencement of the nineteenth century. About the same time as gas lighting began to become practicable, the beginnings of electric lighting made their appearance. The glow in a vacuum tube had been observed by Hawksbee in 1709, and in 1746 Dr. Watson noticed that the sparks between different substances were of different colours, and obtained enough light from an electrical machine to make faces visible. But the discovery of the Voltaic pile in 1800, and of the arc by Davy somewhere between 1805 and 1810, as well as his demonstration of incandescent wires about the same time, were the first indications of the possibility of actually producing light electrically on any useful scale, though these suggestions were forced to remain dormant until more economical methods of current generation were available.

We will now consider briefly the more salient features of the progress of light production during the nineteenth century; taking up first the combustion methods, afterwards the combination of combustion with incandescence, and finally the electrical methods.

Candles have been improved mainly in methods of construction, and by the adoption of new and purer forms of wax. In 1831 De Milly found a means for avoiding the guttering of the wicks, by impregnating them with boric acid, which fused and gave stability to the wick until completely consumed. Chevreul and Gay Lussac in 1825 introduced stearic acid, which was much harder, and less easily melted than tallow. Recently combinations of spermaceti wax with stearic acid have been employed for candles as well as Palmitine, a wax derived from palm oil, while in Germany and Austria ozokerit or cérésine wax is used.

Oil lamps have undergone many modifications from the Argand and Moderator lamps in which vegetable oil was fed up under pressure, to the modern forms employing the lighter mineral oil or petroleum.

In ordinary gas lighting improvements have been made in the form of the burner, and in regulating the pressure of the gas. The early burners were entirely of metal, but this caused a considerable loss of heat through conduction. The most satisfactory substitute has been found to be steatite, which withstands a very high temperature, can be worked into shape, and has a low heat conductivity. The importance of high flame temperature also led Siemen's in 1879 and Wenham in 1892 to introduce regenerative burners, in which the air supplied to the flame was heated by passing over the flame before reaching the burner.

Acetylene.—Although prepared on a small scale by chemical processes as early as 1859, the announcement by Moissan in December, 1892, of the production of calcium carbide by the treatment of carbon and lime in the electric furnace first enabled acetylene to be produced on a large scale. It seems, however, that Wilson, in the United States, in 1888, had noticed the production of carbide in this way, and in 1887, at the Cowles aluminium works, calcium carbide had been accidentally obtained from the union of the carbon with the lining of the furnace. In 1894 Bullier, in France, inaugurated the Société des Carbures Métalliques, which produced crystalline carbide on a large scale by the electric furnace process. The acetylene derived from the immersion of calcium carbide in water burns with a white intense flame; in fact, Nichols has stated that acetylene burning in oxygen gives the most intense light known.

Incandescent Gas.—The ordinary gas flame suffers from two serious defects. In the first place, the light is derived from incandescent carbon particles, which are bad light radiators; and, secondly, the costliness of the gas is considerably enhanced by attempting to make it highly luminous. On this

account various attempts have been made to substitute solid bodies of better light-emitting power, in flames of little or no luminous power, but of high temperature. Berzelius, Bunsen, and Delafontaine, from 1829 onwards, discovered that various of the oxides of the rarer metals were capable of giving a considerable light when introduced into the non-luminous gas flame. One of the first attempts at the improvement of gas-lighting, however, was made by Faraday, who carburetted gas of poor illuminating power, thereby increasing the quantity of solid carbon particles in the flame. This was developed by Dunnovan in 1830 into the albo-carbon light, in which ordinary illuminating gas, or even water-gas, was passed through a reservoir containing naphthalin on its way to the burner. This was applied to street lighting in Dublin, and was rapidly taken up on the Continent.

Before this, however, a solid substance raised to incandescence in a non-luminous flame had been employed by Thomas Drummond in 1826, who invented the limelight. In order to obtain an efficient light by incandescence a great desideratum is a very high temperature, which is obtainable by employing gases of very great chemical affinity, to form a flame of small dimensions, and hence having a small cooling surface. Such a flame is given by the oxyhydrogen blowpipe, and a powerful and comparatively efficient light is obtained when a refractory substance, such as lime, is introduced into this flame. Its defects lie in the difficulty and expense of preparing oxygen, and in the rapid destruction of the lime cylinder, which must be turned to bring fresh surfaces into use.

The latter difficulty was surmounted by Tessie du Motay in 1867, who substituted zirconia for lime; and this, in spite of the use of oxygen, led to a considerable use of this light for buildings, and even for street lighting, in Paris. Improvements both in the form of the zirconia body and in the burner were made by Caron and by Linnemann. The latter realized the conditions necessary for the production of an efficient flame; that the chemical union of the gases should take place a short distance outside the burner, and that the velocity of the issuing gases must be greater than the velocity of flame propagation. Several other workers made improvements on the zirconia light, but the modern incandescent gaslight using an ordinary bunsen flame with lighting gas, and without oxygen, owes its origin to Clamond in 1881. He produced small baskets of calcined magnesia paste, and hung them under an inverted bunsen flame in a platinum wire envelope. About the same time Khotinsky took out a patent for the employment of calcium, strontium, zirconia, &c., in a similar manner, and Lungren, in America, produced caps or mantles of similar materials. As far back, however, as 1839 Alexander Cruickshanks, following Davy, had employed mantles of quartz or of platinum wire covered with lime and in non-luminous gas, and Poapp, in 1882, revived the idea, but with the result that the refractory material soon cracked away from the platinum. The first practical incandescent gas burner for water-gas was that of Fahnejelm of Stockholm in 1883, who employed a comb having rows of needles of kaolin, quartz, zirconia, or other refractory materials, especially magnesia, or dolomitic magnesia, which gave a yellower light.

None of the foregoing devices appear to have been satisfactory with ordinary illuminating gas, owing to the deposition of soot on the glowers. By the use of the argand form of burner, with glowers or mantles of gauze covered with refractory materials, some progress had been made from Brewster in 1820, and Cruickshanks in 1839, to Edison in 1878. But the solution was reserved for Dr. Carl Auer von Welsbach in 1886, who solved the problem of obtaining mantles of refractory oxides without framework, and scientifically investigated the light emission of different substances, as well as improving the burner. Dr. Welsbach found that two of the rare earths, lanthania and thoria, had the property of selective light emission in the green or most economical part of the spec-

trum, but failed to obtain sufficiently coherent mantles with the former. The mantles of thoria were, however, found sufficiently stable, and with the admixture of about 1 per cent. of the dark cerium oxide, gave a very intense and economical light. Many other mixtures were tried, but the above combination was finally adopted. From this time the use of the incandescent gaslight has rapidly extended, but little improvement in principle has been effected. Recently, however, the inverted type of burner has come into use, and the mantle has also been employed in conjuntion with high-pressure gas, oil-gas, as in the Kitson light, and petrol air-gas.

Electric Lighting.—As before mentioned, the development of electric lighting from the experiments of Davy was arrested by the want of suitable generators. But some advances were made, Foucault in 1844 made a simple hand-feed arc lamp, using carbons made by Bunsen from gas carbon baked with treacle, instead of the wood charcoal pencils used by Davy, and Deleuil exhibited this light at the Place de la Concorde. In 1845 Thomas Wright, of London, produced the first self-acting lamp, the arc being formed between bevelled carbon discs, which were automatically rotated, and Le Molt about the same time produced a similar lamp which burnt from 20 to 30 hours. Staite and Edwards in 1846, and Le Molt in 1849 improved the manufacture of carbons for arc lighting, the latter using a mixture of two parts gas carbon, two parts wood charcoal, and one part of liquid tar; which were powdered, mixed, compressed and moulded and were then alternately baked and soaked in treacle several times. Foucault and Dubosq in 1848 devised a clockwork self-regulating lamp, and in 1857 Harrison produced a self-acting lamp, in which the negative electrode was a disc and the positive a carbon rod in a spiral tube fed by clockwork. Before this, however, Archereau in 1848 appears to have made a lamp controlled by a series solenoid, and on the development of lighting after the Gramme machine in 1871, lamps on this principle were devised by Jaspar, Jurgensen, Reynier, Serrin, Crompton, &c., the first arc lamp for series working being probably due to Hefner Alteneck in 1878. The earliest public lighting was, however, carried out by the lamp devised by Jablochkoff in 1878, consisting of two parallel carbon pencils cemented close together. Archereau in 1855 produced carbons by the forcing process, employing very pure charcoal powder, coke, and lamp black, with syrup, which were triturated and passed through a draw plate at 100 atmospheres pressure. The sticks were afterwards baked and dipped while red hot into treacle, this process being several times repeated.

The chief defects of the ordinary arc beyond those of the regulating mechanism, lay in the rapid consumption of the carbons, the low voltage permissible, the comparatively poor light emitting qualities of carbon, and the great loss of light due to the shadow of the negative carbon. To prolong the life of the carbons and at the same time increase the voltage, the enclosed arc was developed by Marks and the Jandus Co. in 1897, the arc being formed in a small nearly enclosed vessel, in which the oxygen was soon consumed leaving inert nitrogen and carbon dioxide behind. This increased the life of the carbon from 8 or 10, to 50 or 60 hours or more, and at the same time enabled a longer arc with a P.D. of 80 volts or more to be employed. On the other hand, Archereau in 1877 had introduced magnesia into the carbons, and Carré also made carbons impregnated with metallic salts. The importance of the selective light emission of such salts was, however, first realized by Hugo Bremer in 1898, who introduced 20 to 50 per cent. of magnesium, strontium, silicon and fluorine compounds as well as oxides of the rare metals. He also got rid of the shadow of the carbons by inclining them and blowing the arc aside with a magnet. Since then the use of "flame" lamps employing carbons with metallic salts has greatly increased, and a great improvement in efficiency has been gained thereby. Recently also Steinmetz has devised the

magnetite lamp in which the positive electrode is of copper, which rapidly conducts away the heat, while the negative electrode is of magnetite or iron oxide, the length of arc being as much as 22 mm. The light in this case comes chiefly from the arc instead of from the electrode, and the duration may be as high as 200 hours or more.

In 1751 Watson formed an arc inside a mercury barometer, and in 1882, Jamin and Manoevrier experimented with arcs between mercury and carbon. Dr. Arons in Berlin in 1892 produced an arc 60 cm. long between mercury electrodes in a horseshoe shaped tube, and Cooper Hewitt in America introduced the mercury vapour lamps in commercial form with inductive device for breaking down the high negative resistance at starting. The light thus produced was very efficient, but of unpleasant colour, and attempts have been recently made to improve it by the use of other metals or by fluorescent materials.

Heraeus now makes a mercury vapour lamp, using a quartz tube, in which the vapour is said to be at a temperature of no less than 5,000° to 6,000°. This lamp is claimed to have no unpleasant colour effects, and its efficiency is probably the greatest ever attained, the consumption being only 0·27 watt per mean spherical candle.

(*To be continued*).

The Annual Meeting of the Illuminating Engineering Society.

THE annual meeting of the society was held on January 10th of this year, when Dr. Louis Bell, the new president, reviewed the progress of the past year. The existence of the society, he said, had been amply justified. No other society could have brought together those representing so many different aspects of illumination, electrical engineers, architects, gas engineers, those interested in acetylene, fixture-dealers, &c. Previously there had been no common meeting ground.

The old hostility between the different sections had arisen through misapprehension. In some cases the differences of opinion had been shown to be unfounded, while in other cases in which disagreement existed the previous bitterness had been replaced by mutual toleration and good-natured criticism.

New Methods of using Acetylene for Lighting Purposes.

By A. Granjon.

In a previous number of *The Illuminating Engineer* Mr. F. H. Leeds wrote as follows :—

"Another serious fault has been that unconsumed gas has frequently escaped from them (acetylene lamps), a matter which has absurdly, though very naturally, left in the layman's mind the almost ineradicable impression that acetylene itself cannot be burned without the production of an unpleasant odour."

It is a fact that acetylene is generally known as a malodorous gas which cannot be adequately utilized for indoor illumination. This idea, of course, is erroneous ; there is no reason why acetylene should escape from the mains confining it in greater quantity than coal-gas, and it may also be said that acetylene, when perfectly purified, as it should be for purposes of indoor illumination, is practically odourless.

It is well known that the odour associated with acetylene is in reality due to the presence of phosphine in the crude product. Were it not for this fact acetylene could be used in the crude state for indoor lighting ; unfortunately, apart from its smell, the presence of phosphine exercises a prejudicial action on mains, burners, &c., and if only for this reason, must be eliminated. Yet such elimination is not absolutely essential for lighting purposes, for it is a matter of fact that the majority of acetylene consumers do not use pure gas.

There is, however, one case in which this purification is quite essential, namely, when acetylene is to be employed in connexion with incandescent mantles. This new application of the Welsbach mantle to acetylene lighting appears to the author to be of such importance as to merit special discussion in this article.

Welsbach mantles are, of course, very generally used for gas-lighting in the present day, and this substitution of incandescent burners in place of the old flat-flame burners arises from the two following causes :—

1. The possibility of improved economy.
2. The possibility of obtaining sources of light of greater brilliancy.

In the case of acetylene the second objection cannot be said to exist, for a single acetylene flame can yield as much as 60 candle-power, which certainly amply suffices for indoor illumination. However, the economy following the use of mantles is sufficiently great to merit the study of this application of acetylene by illuminating engineers. This economy is illustrated by the following example : we may obtain 30 candle-power by burning acetylene under a pressure of 120 mm. either by the use of four ordinary burners, consuming in all 42 litres, or by the use of a single incandescent burner, burning 10 litres. Of course, this saving of 76 per cent. of the original cost cannot be obtained in practice, because the use of incandescent burners is only possible when the gas has been very perfectly purified.

Assuming, however, that the cost of purification is 13 centimes per cubic metre of acetylene (one kilogram of material capable of purifying 12 cubic metres of acetylene costs about 1 fr. 50), we should still obtain a saving of at least 50 per cent.

Another question of great practical importance is as follows : Do incandescent burners require more attention than the original acetylene burners ? We can answer this in the negative.

The mantles used for the acetylene are small in size, and do not break so readily as those usually employed for gas-lighting; we know of many types of incandescent mantles which when in use burn continuously, without causing the least inconvenience to those in charge of the apparatus; in fact, the use of incandescent mantles dose not unduly complicate acetylene lighting.



FIG. 1.

We may next inquire by what class of consumers will incandescent mantles, in conjunction with acetylene, be utilized?

Naturally people who consume acetylene for home-illumination, irrespective of expense, will not adopt it, but such people are rare. Recent statistics compiled by the Office Central d'Acétylène show that nearly 80 per cent. of the acetylene generated is used for the lighting of shops, restaurants, &c., in small towns and villages. The author believes that those who require both a good and a cheap light will readily adopt the new method of illumination capable of realizing so great an economy, and that the incandescent burner will also find ready use in small towns and villages where the street lighting is accomplished by a central station; the majority of acetylene street lamps in France and Germany are provided with incandescent burners.

In short, he is inclined to think that incandescent burners will be employed in most cases where acetylene is in actual use, but that the new process will not very considerably increase the number of acetylene private supplies. It will, however, greatly facilitate the exploitation of acetylene central stations, by enabling them to reduce the price of acetylene to consumers.

The great inconvenience following the use of acetylene for house-lighting consists in the necessity of the consumer himself being obliged to pay attention to the apparatus. For the user of acetylene must possess in his house a miniature generating works, and while acetylene probably requires less attention than oil lamps, it is still open to objection on this ground.

To reduce this inconvenience the idea of employing dissolved liquid acetylene in cylinders was suggested. The liquid, however, proving to be dangerous and explosive, was soon forbidden by the public authorities. The question was still unsolved, until Messrs. Claude & Hesse discovered a method of dissolving acetylene in acetone, a cheap and volatile material, possessing the power of dissolving 240 times its own volume of acetylene under a pressure of 10 atmospheres at 15 degrees Centigrade. The inexplosive method of solution being thus realized, the exploitation of the process was undertaken by the Cie. d'Acetylene dissous (Dissolved Acetylene Co.). Cylinders containing acetylene dissolved according to this process are now in the market, and have found great application both for lighting and in-

dustrial purposes. These cylinders are simple to manipulate, compact, portable, and yield only pure gas. Acetylene produced from them is, of course, dearer than that produced in the ordinary way, and the cylinders themselves, being of considerable value, must be returned after use. Hence dissolved acetylene may only find ready application in the case of easily accessible towns and villages. Its chief application will probably be to automobiles and railway-lighting, and the majority of the motor-cars running in Paris are already lighted by this means.

On the French Northern Railway many carriages are lighted by dissolved acetylene, and the results of using this new method of illumination are said to be satisfactory.

Fig. 1 represents special arrangements used for motor-car lighting.

In Fig. 2 are shown two cylinders as ordinarily employed for house-lighting.

In both cases the set of two cylinders is provided with an expansion arrangement and a monometer. 350 litres of acetylene, under a pressure of 10 atmospheres, can be dissolved in a single bottle. A couple of bottles containing 700 litres are amply sufficient for motor-car lighting, when it is borne in mind that the burner employed in this usually consumes from 10 to 20 litres of acetylene per hour.

Yet, although dissolved acetylene is a very convenient and simple method of attacking the problem, it is quite possible that the process may only find application in the special cases previously enumerated. The great objection to its universal adoption is the high price of the gas itself—about three times as dear as that generated in the ordinary way. This high price is chiefly due to the enormous capital expended in exploitation, and it seems at present improbable that dissolved acetylene will ever be very generally employed for indoor illumination.

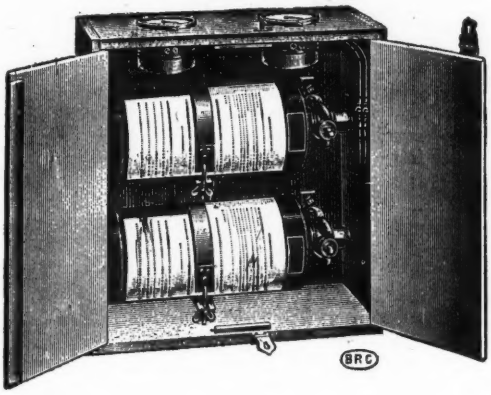


FIG. 2.

Artificial Illumination and the Education of Those Concerned in its Production.

By Charles W. Hastings.

(*Continued from p.* 123.)

Continuing the discussion of the education of those engaged in illumination, we must for purposes of comparison refer very briefly to the subject of electric lighting.

In the first place it cannot be denied that the student of electricity was, from the start, a man of distinctly better general education than the gasmaker, to whose failings and shortcomings we referred in a previous chapter; he brought to bear upon the special study a knowledge of higher mathematics, physics, and chemistry. He had for his mentors men well known in the scientific world, as witness those who gave evidence in the promotion of the Electric Lighting Act, 1882. Whatever the faults of that particular Act may have been, there were marshalled before the Select Committee of the House of Commons men of high scientific and intellectual attainments. The principal witnesses were: Sir Frederick F. Bramwell, Mr. William Spottiswoode, Dr. Charles W. Siemens, Dr. John Hopkinson, Sir John Lubbock, Mr. Edward H. Johnson, representing Edison's interest in electric lighting, and Mr. R. E. Crompton; the last named gentleman was, we believe, the first electric light engineer in this country.

It is interesting to glance through the minutes of evidence, and to read the opinions of these able men upon the future of electric lighting; of those we have named several have passed away, but all lived to see electric lighting successfully installed and in keen competition with gas for both public and private illumination. So we find that the electric lighting engineer had reason to be proud of his sponsors. The class of men who went in for electric lighting had means; many of them were graduates of the universities—Oxford, Cambridge, Dublin, Edinburgh, &c. Others were students from Owens College, Manchester, Mason College, Birmingham, and similar semi-technical colleges, which have in these latter days been merged into the modern universities. Lectureships in electrical engineering were established, and to-day we find that a department of electrical engineering is associated with practically all the newer universities.

Particulars of such a section are before us. The Professor is a D.Sc. of London, the Assistant Lecturers are respectively B.Sc. of London and M.Sc. of Victoria (Manchester). In the Elementary Course no special study is made of electricity as an illuminant, but in the second year electric lighting is included in both the lecture and laboratory course. So it will be seen that it is possible for a young man to prepare himself theoretically, and, to a certain extent, practically, whilst at college for the position of an electric lighting engineer.

It has become a common practice for large firms of electrical engineers to receive graduates from the universities as pupils, and to make special terms and arrangements for their articles. In this way the graduate acquires a thoroughly sound and practical experience, and enters upon his career with a very different knowledge of the possibilities of electric lighting to that of his illuminating brother, the gas engineer.

Looking down the list of persons qualified as teachers in connexion with the Department of Technology of the

City and Guilds of London Institute, we find, under the heading 'Electrical Engineering,' ninety-eight men; of these twenty-eight are graduates. The department 'Gas Engineering and Supply' have only twenty-four teachers, none of whom are graduates; few, we think, are members or even Associates, of the Institution of Civil Engineers. Only three possess qualifications other than everyday experience. Two of these are Fellows of the Institute of Chemistry and one a Fellow of the Chemical Society.

It must therefore be admitted that notwithstanding the enormous capital invested in gas undertakings—approximating 125,000,000*l.*—the education of those responsible for the profit-return upon this capital has not had the consideration that it deserves.

Following up the question of the possibilities of studying the science of illumination as regards gas lighting, we will look back upon one or two of the steps that have been taken to instruct, if not to educate, the gas engineer.

Primarily his work has been to make gas, and it is only within the last two or three years that any consideration has been given to the question of the best method of utilizing gas for illuminating purposes.

The directors of the companies or the committees of corporations owning gas undertakings have been alike quite indifferent to this exceedingly important question.

The sale of gas is to-day controlled by the somewhat ancient Sale of Gas Act, passed in 1859. Under the City of London Gas Act, 1868, the appointment of gas referees was established. These gentlemen issue annually their notifications, and from about that time up to the passing of the London Gas Act in 1905, they permitted and enforced the use of Suggs' London Argand Burner, as the legal standard for testing gas. No one ever appears to have thought it necessary to legally test gas for its luminosity when in actual use; no indisputable data exists as to the penetrative power of gas illumination, its intensity at the point of flame, or the loss of luminosity at stated distances from the burner.

From time to time elaborate papers have been read at meetings of gas engineers, but the figures have never been, so far as we know, standardized. To-day, just as years ago, photometrists give elaborate laboratory results instead of those obtained in actual practice, which might become golden rules for all interested in illumination.

An elaborate report upon testing gas by candle was recently presented by a special committee to the American Gas Institute, in which compilers show that much disagreement exists as to the best method of arriving at the candle-power. The Harcourt 10 candle Pentane lamp is now the standard for the district under the control of the Gas Referees, and covers the London County Council area. It is hoped that at no distant date it will be universally adopted throughout Great Britain as the "candle" illuminant, but even then it simply means uniformity in the laboratory.

The gas engineer—or the illuminating engineer, as our Editor would prefer us to say—needs to know more about the actual volume of light at his disposal. How is he to acquire this knowledge? Who is to teach him? There are no special textbooks worth his study. As we write we have upon the table half-a-dozen books issued within the last six months. In all of these otherwise excellent publications the sections dealing with illuminating power give only stereotyped information set out in different form. Reading one after another we find ourselves "no forrader."

Prof. Vivian B. Lewes, in 'Liquid and Gaseous Fuels,' devotes some space to the 'Structure and Proportions of Flame.' He illustrates his remarks and shows examples of the Cockspur and Cockscomb burners, which have been before the public as stock illustrations for many years. His next illuminating picture is the reproduction of an 'Old Flat Flame Burner.' The subject of illumination is dismissed with the briefest reference to the Siemens, Wenham, and Cromartie regenerative burners. The chapter is

concluded with some forty or fifty lines upon the discovery of the incandescent mantle and the Welsbach burner.

Take the next, Henry O'Connor's 'Gas Engineer's Pocket-Book,' which contains much that is useful and but little that is new. The section treating of 'Illuminating Power and Purity of Gas' is simply an extract from the Gas Works Clauses Act, 1871, and the notification of the Gas Referees revised to August, 1906, *verbatim et literatim*, with the appendices thereto. This is all the author gives to help educate the illuminating engineer.

Another volume is 'Chemistry of Gas Manufacture,' by H. M. Royle. In this admirable book Chap. xi. is headed, 'Photometry and Gas Testing.' It opens with references to Kepler's 'Law of Inverse Squares,' Lambert's 'Cosine Law and the Generalized Photometrical Law.' These three rules he states "form the basis of all photometrical works, no further study of physics is absolutely necessary for the comprehensive study of photometry." The author describes very briefly several standards, and refers to Appendix A, which we find, upon turning to the end of the book, to be the notifications of the Gas Referees, set out fully, and occupying some forty-eight pages!!

In Mr. W. F. A. Butterfield's book, 'The Chemistry of Gas Manufacture,' only very slight reference is made to the illuminating power of gas; but we hope that as the author is engaged upon another volume covering the 'Testing and Use of Gas,' that he may be able to strike out something more original than the Gas Referees' notifications, and at least bring the study of illumination into line with modern thought and practical necessity.

We will conclude this chapter with a reference to, and a hearty appreciation of, Mr. Walter Hole's 'Distribution of Gas,' an expensive book, but one written by a man who knows and who has done his best to bring together illustrated details of all the best systems, methods, and apparatus connected with illumination by gas. There is much in the book which should be studied by all illuminating engineers. Mr. Hole has set himself the task of dealing with the distribution of gas from the station meter to the burner, confining himself, however, to public lighting, and leaving, probably for another volume, domestic illumination.

In the next chapter we shall venture to sketch a short syllabus, which we trust will aid the student who intends to qualify himself for the position of illuminating engineer.

(*To be continued.*)

The Advantages of the Metallic Filament Lamp for Low Voltage, Isolated Plants.

By An Engineering Correspondent.

It is proposed to demonstrate in this article the particularly useful field for the metallic filament lamp, when used with small private electric lighting plants.

The writer is enabled to supply some actual cost figures on a small gas-driven plant, which was originally installed to light twenty-five 8-c.-p. carbon glow lamps.

A terminal pressure of twenty-five volts was adopted in order to keep the initial cost of the storage battery as low as possible. The plant consists of a 2¾ B.H.P. gas engine driving a 1·5 K.W. 25–35 volt dynamo, in conjunction with a storage battery. As not more than 750 watts are required to light twenty-five 8-c.-p. lamps, an ample margin of power is available for charging the battery during lighting hours. Fourteen cells, of 120 ampere hour capacity at a nine-hour discharge rate, are installed, sufficient to run about eleven 8-c.-p. lamps for nine hours.

It is interesting to note that an open type arc lamp, using flame carbons, burns quite satisfactorily on this circuit, at the charging voltage of 28–34 volts, the current consumption being about 10 amperes.

Great care has to be taken with all connections to switches and fittings at this low voltage, because a loose screw, and consequently high contact resistance, causes a drop of 1 volt or more, which, at a pressure of 25 volts, will result in 8–10 per cent. decrease in the light.

The first metallic filament lamp was tried on the circuit at the end of the year 1904, this being a 25 volt 16 hefner candle-power Osmium lamp. This lamp was tested for candle-power and watt consumption every 100 hours, and finally burnt out after 960 hours' use. The results of the first and last tests on this 16-c.-p. 25-volt Osmium lamp are given below.

Hours of burning.	Candle-power (British).	Watt consumption.	Watts per candle-power.
0	15·1	24·4	1·62
900	12·5	23·8	1·9

After the completion of this test it was decided to extend the use of the Osmium lamp, in spite of its high price, for the following reasons :—

1. Greatly reduced current consumption.
2. Reduced voltage drop on remote lamp circuits.
3. Reduced sensibility to voltage fluctuations, which are unavoidable on small gas-driven plants.

Osmium lamps were at first rather difficult to obtain, and even the 25-volt lamps were very fragile, as compared with the more recent forms of tungsten lamps, therefore it was not until the tungsten filament lamps were on the market that reliable cost results could be obtained.

The output from the plant has not been appreciably reduced by the use of these metallic filament lamps, but the opportunity has been taken to light another house, and also to increase the candle-power standard. The average costs of generation of current per unit will be given. These costs will serve for the former installation of carbon filament lamps, and the recent installation of metallic filament lamps. In these costs, gas, oil, and depreciation charges only are taken into account, labour charges not being included, as the lighting plant is run in conjunction with a workshop, thus not occasioning

the employment of special labour to attend to the lighting plant.

If it were necessary, with a small installation, to employ some one merely to attend to the plant, the wages bill would run up the cost per unit to an abnormal figure.

In many cases it is practicable to train some one to attend to an installation in addition to their other duties, as a small plant does not require a great deal of attention.

Number of units used, and average cost of same, during a period of twelve months.

Total number of units	690
Cubic feet of gas	57,000
Cubic feet per unit	83
6 gallons of oil at 3*s.* per gallon ...	18*s.*
Engine depreciation per annum taken at	30*s.*
Dynamo do. do. ...	10*s.*
Battery do. do. ...	20*s.*
Sundries	8*s.*
Cost per Unit.	
Gas at 2*s.* 3*d.* per 1,000 cubic feet ...	2·24
Oil	0·31
Plant depreciation	1·04
Sundries	0·14
Total cost ...	3·73

Or about 3·75*d.* per unit.

The total installation of tungsten filament lamps now consists of thirty 10-c.-p. (hefner) and twenty-four 16-c.-p. (hefner) lamps. Both the carbon and the metal filament lamps have an average life of over 1,000 hours on this low voltage, this probably being due to the much greater strength of the filament, as compared with standard high voltage lamps. The carbon lamps were renewed once per year, although in many cases not being actually burnt out, but on account of the decrease in candle-power.

The average number of units consumed per 8-c.-p. carbon lamp per year $= \frac{690}{25} = 27{,}600$ watt hours. At 30 watts per lamp this gives an average of 920 hours useful life per lamp.

The cost of lamp renewals per 1,000 candle-hours, at 15*d.* each, is therefore $\frac{15 \times 1000}{920 \times 8} = 2{\cdot}05d.$ for renewals per 1,000 candle-hours, or per kilo-candle hour.

The tungsten filament lamps now in use are not renewed until the filaments are burnt out, as the decrease in candle-power during life is not nearly so noticeable as with the carbon lamps.

One of the original Osmium lamps burnt for over 2,000 hours before giving out, and was then giving at least 75 per cent. of its original candle-power.

Allowing the average life to be 1,000 hours for tungsten lamps, and the price 3*s.* per lamp (25 v.), the renewal costs will be as follows :—

$\frac{36 \times 1000}{1000 \times 10} = 3{\cdot}6d.$ per kilo. candle-hour.

The current costs per 1,000 candle-hours are as follows :—

Carbon lamp 3·75*d.* × 3·75 watts per candle 14*d*
Tungsten lamps 3·75*d* × 1·3 do. do. 4·9*d*
Total costs per kilo-candle-hour (carbon) 16*d*
do. do. do. (tungsten) 8·5*d*

thus reducing the cost of light to nearly one-half.

It has been possible to increase the total candle-power from 200 c.-p. to 600 c.-p., no additional plant being required, the only extra cost being for lamp renewals. Below are given the total costs per year, the current consumption being taken at 690 units.

Type of Lamp.	Total candle power.	Cost for current.	Cost of lamp renewals.	Total cost per year.
		£	£	£
Carbon ...	200	11	1·5	12·5
Tungsten	600	11	7·5	18·5

In the distribution of electricity, high voltage circuits are employed chiefly to keep the cost of the mains and leads as low as possible. But in determining the cross section of the conductor for electric lighting purposes, in the branch wires it is frequently necessary to consider the mechanical strength in addition to current-carrying capacity.

The smallest size wires used in practice are S.W.G. 18 and S.W.G. 3/22, each having a copper cross section equivalent to ·0018 square inches. At a current density of 1,000 amps. per square inch a current of 1·8–2 amperes is obtained, using the smallest permissible wires consistent with mechanical strength. As it is usual, with parallel systems of wiring, not to place more than two or three lamps on one circuit, it is obvious that the introduction of the metallic filament lamp

at lower voltages will not occasion any higher costs for copper, as far as the individual circuit wiring is concerned.

Take the comparison between two installations of 16 c.-p. lamps, one consisting of 100-volt carbon lamps, and the other 25-volt tungsten lamps. The 16 candle-power 100 volt carbon lamps require ·6 amperes each, and the 16 candle-power 25 volt tungsten require about ·7 amperes each, therefore approximately the same cross-section of copper would be required in each case. Therefore where a four to one reduction in voltage is made, no extra cost is occasioned for increased section of cables or wires where the low voltage system with tungsten lamps is employed.

The low voltage system has, in addition, the following advantages :—

1. Absolute safety from shock.
2. Reduced fire risks, owing to lessened possibility of leakage.
3. Superior lamps, having a much less fragile filament, and capable of being used in other than vertical positions.
4. Possibility of obtaining single lamps of relatively small candle-power (10–16 c.-p.).

In the following table, suitable voltages are given for small plants, supplying lighting installations using tungsten lamps.

No. of lamps installed.	Candle power per lamp.	Total watts.	Suitable voltage.	Full load current.
25 or 18	10 14	300	14	21·5
33 or 25	12 16	500	16	31
80 or 50	10 16	1,000	25	40
100	16	2,000	25	80
200	16	4,000	50	80
400 or 250	16 25	8,000	50	160
500 or 400	25 32	16,000	100	160

Up to the present, many people who are not situated in the area of an electric supply company have not been able to make use of the electric light, on account of the large capital outlay necessary for a private generating plant. This outlay will be largely reduced in an isolated plant designed to supply an installation of tungsten lamps.

For purposes of comparison, the following table has been prepared from recent catalogues of engine-makers and manufacturers of electrical plant, and serves to show the difference in capital outlay required for plant, for installations of carbon and tungsten lamps, for a given number of lamps of equal candle-power. These prices vary with different makers, but will be useful for purposes of comparison.

No. of 16 c.p. lamps.	Capital outlay required for generating plant, including engine, dynamo, storage batteries, and switch-gear.	
	Tungsten lamp.	Carbon lamp.
	£	£
15	36	60
25	44	73
50	63	113
100	92	187
200	130	270
400	200	420
800	300	720

From the preceding table of figures, it will be noticed that the cost of plant for an installation of fifteen 16 c.-p. tungsten lamps is reduced to 60 per cent. of the cost of plant necessary for an installation of fifteen 16 c.-p. carbon lamps, while in a large installation of 800 lamps the cost of plant is reduced to 40 per cent.

The new metallic filament lamp should therefore open up a fresh field for electric lighting by means of isolated plants, and better enable it to compete with coal or acetylene gas as regards capital outlay and working costs. However, when current is obtainable from a supply company, it is usually cheaper to take the current from their mains, the source of supply being more reliable, and it is much more convenient when the light is only required for intermittent periods.

The International Electrotechnical Commission.

In September, 1904, an International Electrical Congress was held at St. Louis, Prof. Elihu Thomson being the President and Dr. A. E. Kennelly General Secretary.

Colonel R. E. Crompton, C.B., read a paper before the Congress which resulted in the adoption of the following resolution by the Chamber of Government Delegates :—

"That steps should be taken to secure the co-operation of the technical societies of the world by the appointment of a representative Commission to consider the question of the standardization of the Nomenclature and Ratings of Electrical Apparatus and Machinery."

A great deal of preliminary correspondence took place, which finally culminated in a preliminary meeting being held in London in June, 1906, at which fourteen countries were represented. Mr. Alexander Siemens was in the chair, and a set of rules which place every country, large and small, on an equal footing as regards voting power and taxation, were adopted, and now await ratification by the authorities by whom the delegates were appointed.

The late Lord Kelvin was elected the first President, and Col. Crompton was appointed the first Honorary Secretary.

Electrotechnical Committees have now been formed in Austria, Belgium, Denmark, England, France, Germany, Hungary, Mexico, Spain, Sweden, and the U.S.A., and the matter is also being considered in several other countries.

The British Institution of Electrical Engineers have taken a very prominent part in this work, for they not only defrayed the preliminary expenses, but granted the Commission a very substantial loan, so that the work of organization should not be hampered at the commencement.

The British Electrotechnical Committee have appointed two Sub-Committees, one to deal with nomenclature, and the other with symbols. The Sub-Committee which is engaged in drawing up the list of terms, with their explanations, in use in the electrical industry will, of course, include the nomenclature of illumination in their glossary, and the decisions of the International Photometric Commission have already come under the official notice of the Committees with a view to being considered internationally.

The attention of the Committees is being confined, as far as possible, to the question of nomenclature and symbols, which form the basis of the work of the Commission, the more difficult subjects being deferred until later.

The new President is to be formally elected at a meeting of the Council, which will most likely be held in London in the autumn.

STANDARD SYMBOLS FOR WIRING PLANS

AS ADOPTED AND RECOMMENDED BY

THE NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION OF THE UNITED STATES.

COPIES MAY BE HAD ON APPLICATION TO THE SECRETARY, UTICA, N. Y.

Ceiling Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Ceiling Outlet; Combination. ½ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

Bracket Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Bracket Outlet; Combination. ½ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

Wall or Baseboard Receptacle Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Floor Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Outlet for Outdoor Standard or Pedestal; Electric only. Numeral indicates number of Stand. 16 C. P. Incan. Lamps.

Outlet for Outdoor Standard or Pedestal; Combination. ½ indicates 6-16 C. P. Stand. Incan. Lamps; 6 Gas Burners.

Drop Cord Outlet.

One Light Outlet, for Lamp Receptacle.

Arc Lamp Outlet.

Special Outlet, for Lighting, Heating and Power Current, as described in Specifications.

Ceiling Fan Outlet.

S^1 S. P. Switch Outlet.
S^2 D. P. Switch Outlet.
S^3 3-Way Switch Outlet.
S^4 4-Way Switch Outlet.
S^5 Automatic Door Switch Outlet.
S^6 Electrolier Switch Outlet.

Show as many Symbols as there are Switches. Or in case of a very large group of Switches, indicate number of Switches by a Roman numeral, thus; S^3 XII; meaning 12 Single Pole Switches.

Describe Type of Switch in Specifications, that is, Flush or Surface Push Button or Snap.

Meter Outlet.

Distribution Panel.

Junction or Pull Box.

Motor Outlet; Numeral in center indicates Horse Power.

Motor Control Outlet.

Transformer.

Main or Feeder run concealed under Floor.

Main or Feeder run concealed under Floor above.

Main or Feeder run exposed.

Branch Circuit run concealed under Floor.

Branch Circuit run concealed under Floor above.

Branch Circuit run exposed.

Pole Line.

Riser.

Telephone Outlet; Private Service.

Telephone Outlet; Public Service.

Bell Outlet.

Buzzer Outlet.

Push Button Outlet; Numeral indicates number of Pushes.

Annunciator; Numeral indicates number of Points.

Speaking Tube.

Watchman Clock Outlet.

Watchman Station Outlet.

Master Time Clock Outlet.

Secondary Time Clock Outlet.

Door Opener.

Special Outlet; for Signal Systems, as described in Specifications.

Battery Outlet.

Circuit for Clock, Telephone, Bell or other Service, run under Floor, concealed.
Kind of Service wanted ascertained by Symbol to which line connects.

Circuit for Clock, Telephone, Bell or other Service, run under Floor above concealed.
Kind of Service wanted ascertained by Symbol to which line connects.

NOTE—If other than Standard 16 C. P. Incandescent lamps are desired, Specifications should describe capacity of Lamp to be used. Copyright 1906 by the National Electrical Contractors' Association of the United States.

Factory Lighting.

By an Engineering Correspondent.

Factories, inasmuch as they must be placed in a category of their own, resemble churches, but with that one point of similarity the likeness ends. In my last article on 'Church Lighting,' I endeavoured to emphasize the necessity for placing art before utility; of paying special attention to the harmonizing and blending of the lighting effect with the general scheme of architecture; of avoiding anything that might jar in the slightest degree on the senses of the beholder, or of distracting his thoughts by lights placed where they were a source of discomfort. It is true that no extraordinary difficulties have to be overcome, or artistic problems solved in the illuminating of factories, but there are nevertheless certain conditions that obtain in this work that are not encountered in any other class of buildings.

The main considerations are economy and effective lighting, and it is to be remembered that the lighting has to be applied not for purposes of display, nor for the benefit of an onlooker, but for the purpose of assisting the employee in his work. Factory lighting requires very careful attention on the part of the electrical engineer who is entrusted with the carrying out of such work as a contractor, or who is required to draw up a scheme to be followed out and adhered to by another who does the actual installation work; and so much work of an unsatisfactory nature has been carried out in the past in buildings of this character, that the importance of having the system planned out and laid down in accordance with the laws of illumination cannot be neglected by the owners of such premises. It has been said that it is not only the hygienic conditions affecting the well-being of the workpeople that have been neglected, but that many installations have been badly designed, and consequently wasteful and inefficient as regards consumption of current.

Doubtless this is more true than is generally supposed, for it is possible to have lights fixed as to produce brain fag or strained eyesight in those working with them, as well as placed in positions where they are not of great use, as well as in places where they are not required. All these points lead to increased cost of production, either on account of downright wastefulness and extravagance, or by reason of decreased output on the part of the workmen. It is common knowledge that investigations into illumination and its relation to output were made many years ago in connexion with a cotton mill in this country, and we learn that the improvement in the lighting not only increased the output, but also reduced the number of wastes, or "seconds" that were made, thus showing improved economy on both accounts. From this it is evident that an intelligent study of the subject is required, and that the old happy-go-lucky plan of installing lights where it was most easy to find proper fixing must give place to the carefully thought out scheme whereby waste will be reduced to a minimum, and every light placed so as to be utilized to the fullest advantage.

To begin with, it is at once evident that factory lighting consists in almost every case of general and applied illumination There are large floor spaces without closely placed benches and machinery, such as the bobbin winding rooms in lace factories, or sorting rooms, where the small individual light units are not required. On the other hand, there are benches

and machines where it is necessary that lights shall be so placed as to give a suitable illumination on some particular object. An illustration of this is well seen in foundry work, where the general casting floor may be taken as an example of space lighting, but the operations of making the more delicate moulds and cores require light directly applied to the work in hand. And for this reason it would appear that in the majority of cases mixed lighting, by means of arc or mercury vapour lamps for open spaces, with small incandescent units for the applied processes, would be most suitable. Between the two extremes will be found small spaces which are not sufficiently large to need an arc lamp, but which, if lighted by incandescent lamps, would be more costly than was advisable. For such positions large Nernst or high candle-power Tantalum or Osram lamps should be used. The province of the illuminating engineer is to study the special requirements of every part of the building he is dealing with, and advise or act according to the laws of lighting.

In the majority of cases factories are supplied with current from their own plant. Out of some eighteen or twenty large factories in which the writer has installed electric light and power, only some two or three were connected to a central station supply. The reason for this is not far to seek. Factory lighting cannot be considered as a valuable acquisiton to the supply company unless the hours of working keep the load out of the peak. Of course, in the case of factories working night and day shifts alternately throughout the year, as in the case of most lace factories, for twenty-four hours per day, the matter is different, as the long-hour output pays for the inconvenience of having the factory load synchronize with the shop lighting load for an hour or so. But, unfortunately for the station engineer, these are the very factories who prefer to install their own plant; the customers who are anxious to be connected are those who only require a supply of energy for lighting purposes for a very few hours per diem, and this at the same time when every one else requires current also. For this reason electric lighting authorities are unable to offer such premises any lower terms—by which I mean terms calculated on a maximum demand system—than other customers, with the inevitable result that the coupling-up is not only productive of no profit to the suppliers, but is a fertile cause of complaint, on account of high charges, on the part of the factory owner. There is no doubt but that this is the reason that so many factories have retained their old gas systems, or, when driven to change, installed some high pressure method of gas-lighting. This problem of cost of current will no doubt be simplified in the near future, when the electric drive on the group or individual machine principle is more largely adopted than at present, but to-day, in the majority of cases, factory lighting must be considered from the point of view of the private plant.

It is outside the province of this article to consider this in detail, except so far as relates to the arrangement of lighting from the standpoint of the illuminating engineer who has decided that electricity is the medium most suited to the requirements of the particular building.

The majority of modern factories are built on one level, the arrangement followed being in the form of a series of bays, in which natural light is utilized to the fullest extent by glazed roofing. These bays are supported on iron or steel pillars, and tied and braced with steel rods, thus affording but little assistance to the installation contractor during the wiring. As a general thing the plan of progressive dealing with the goods is adopted, the raw material being sent in to the material stores or sorting rooms at one end, and the stores for the finished articles, and the delivery bays being at the other. It is usual, seeing that natural light is not so much required in the latter stores, to build the offices above these, and overlooking the factory generally. The space and applied lighting, in such a building can be dealt with very easily, and the whole business is much more simple than

in the older type of storied factories, where the only natural light is obtained from side windows. In these there is but little space lighting, as the benches, &c., where the actual manual labour is carried out are fixed under these windows, so that artificial light has to be arranged in small individual units to illuminate these benches. The machines are placed in the centre of the rooms as a general thing, and owing to this small light units have again to be provided; there being consequently but little opportunity for utilizing arcs or high candle-power lamps in any except packing or store rooms where the throwing of shadows is not so material a disadvantage. Experience has taught that no hard-and-fast rules can be laid down to meet the many varied conditions that are to be found in such buildings, and that every factory must be the subject of particular and separate study before any decision can be arrived at as to the type of lamps to be used, or their best positions be determined.

Where space lighting can be dealt with there are a number of suitable lamps which could be installed, and the question of area and height will be important factors for consideration. In some buildings, owing to the height being suitable, some admirable results have been obtained by arc-lighting alone. For example, in the very extensive works of Messrs. Napier, of Acton, the well-known motor car builders, some hundreds of flame arcs have been installed, to the entire or almost entire exclusion of smaller lighting units. The lamps, run four in series, are hung at a uniform height of twelve feet from the floor, and it is said that so perfect is the effect obtained that even the most delicate of operations can be carried out without difficulty. It is evident that such lamps could be arranged so as to kill all shadows, and give even illumination throughout. But it is but seldom that a factory is met with where such a method could be adopted in entirety with such success, and in the majority of cases mixed lighting must of necessity be installed.

For space lighting, the most suitable lamps, where there is sufficient height, are undoubtedly those of the flame arc type; and in cases where accurate colour rendering is of the slightest importance, as in practically all textile, litho, cleaning and dyeing, or colour printing works, lamps of the pure white, daylight effect, as those made under "Carbone" patents, are far superior to those obtaining their flame effect from the use of impregnated carbons. But where top space is not available, smaller arcs, as the "Radiant," or similar small white light arc lamps, consuming about three amperes will give a good effect, and can be easily arranged in the majority of cases so as to kill all (or practically all) shadows. The Nernst lamp is particularly suited for small space lighting, and has been adopted more largely in America than in this country, where it is for some reason not popular amongst contractors. But for foundries and low-ceiling machine shops it answers admirably, and when installed at a standard height of about nine feet, and spaced from eight to ten feet apart, gives excellent results. An argument in its favour is the low current consumption, although against this has to be placed the cost of renewals, which at one time represented an appreciable amount. It is only right to mention here, however, that the makers claim to have discovered the cause of the frequent failures of these lamps, and to have rendered the Nernst lamp as reliable as any other.

The value of the new metal filament lamps has yet to be thoroughly tested for factory lighting, since up to the present very little reliable data can be obtained. The question of vibration has to be taken closely into consideration, and the matters of life and depreciation must be taken into account. Their great advantage lies in their low specific consumption of energy, and it is probable that with the high candle-power lamps of this type better results as regards light and economy could be obtained than with any other lamp. It is too soon, as has been said, to speak authoritatively as to these, but the choice is already large and is certainly likely to become larger. As

a matter of fact, metal filament lamps are quite in their infancy. Many large and well-known lamp-makers have not as yet completed their arrangements, and are no doubt going very closely into the subject, with a view to overcoming some of the disadvantages and weaknesses which are inseparable from all new departures.

In many cases of lighting the carbon lamp, in spite of the fact that compared with other types it is not economical in current consumption, as yet holds its own, as it withstands almost any amount of vibration, and can be used, as indeed can the "Tantalum," in any position. But it is not probable that the carbon lamp will occupy this position of superiority for any lengthy period, in view of the improvements in metal filament lamps that have been foreshadowed, and which may indeed be confidently expected. But at the present it more than holds its own for factory lighting, particularly if care is taken to install a high grade lamp. But it is with the arrangement of these small light units that the opportunity for economy comes, and it is in this respect that work carried out by a contractor who has studied the science of illumination will be superior in every respect to that carried out by one who has no further thought than to put in a light wherever some one, whether architect or factory owner, recommends it, or consideration of price per point affect the decision. In many instances the usual practice is to install a sixteen candle-power lamp at each machine, and it has been said that this, although not always considered altogether suitable by the illuminating engineer, has the sanction of custom and the hearty endorsement of those who are under the impression that only by this means can the same rate of output be obtained by artificial as by natural light. An interesting statement was made before the Chicago section of the Illuminating Engineering Society last year, to the effect that a bare lamp placed thirteen inches above the face plate of a drill press and seven inches from the centre gave when new and clean an illumination of five and a half foot candles at the centre of the plate, whilst an old and dirty lamp only gave approximately one and a half foot candles. From this it will be seen that a good deal depends on the illuminating engineer inside the factory, whose duty it is to keep the bulbs clean and in good order, and to install new lamps where and when necessary. If lamps are allowed to burn until they are black inside and coated with dust and dirt, even the best results of arrangement are nullified, and dissatisfaction certain to arise.

One point may be mentioned, and that is the matter of shades. Even in space lighting efforts should be made to ensure as much light as possible being thrown in a downward direction —except in cases where a suitable white ceiling makes diffused lighting admissible; and in applied lighting enamelled iron shades of sharp angle should always be used. With a suitable shade an eight candle-power lamp will give as good a result as a sixteen, with consequent reduction in cost of energy; and in many cases special reflectors of the poke-bonnet type will be even more suitable.

And so, to sum up, we have arrived, after due consideration, at the fact that in lighting workshops and factories, the services of an illuminating engineer who will intelligently study the individual requirements of each building are more than necessary, and are absolutely essential to ensure adequate, efficient, and economical lighting.

The Standardization of Coloured Glasses Applied to Illuminated Signals by Night.

By Auguste Pihan,
Director of the Lighting Laboratory of the French Northern Railway.

Coloured glasses have been for a long time applied to night signals, and it would seem that these should, therefore, be the subject of careful standardization; nevertheless, we have had occasion to observe that the depth of colour given to these glasses often bears no relation to the intensity of the source of light used to illuminate them, and that their utility is considerably restricted in consequence.

We often notice, for instance, that such signals show different colours from those demanded by the regulations applying to them; it is, therefore, the author's intention, in the course of this article, to indicate the conditions which make for the most perfect utility, and the lines on which a judicious choice of the coloured screens utilized in connexion with signal-lights should proceed. He proposes in what follows to define standards for glasses of various colours, and describe the practical method of testing them adopted by him.

Examination of Coloured Glasses.—Coloured glasses intended for signals should not be examined by daylight, but by the aid of the particular variety of light by means of which they will be illuminated under practical conditions. For the light passing through such a coloured glass depends not only on the nature of the metallic oxide used to tint the glass, but also on the spectral composition of the illuminating sources; thus certain blue glasses, when illuminated by sources rich in red and yellow light, may appear violet or even green, while many glasses which appear a beautiful violet under daylight conditions assume a nondescript hue when illuminated by artificial light.

The importance of establishing standards of colouration becomes evident when we consider the frequent application of such apparatus in connexion with the railways. For each particular colour, green or red for example, certain limits of colouration ought to be established, and a maximum and minimum laid down for the permissible variation of samples submitted for test. In the case of blue and violet, which necessarily absorb a large proportion of the light falling upon them, it is essential to establish one single standard of colouration for reasons which will appear later.

Method of comparing Glasses of a certain Colour among Themselves.—In making these measurements a convenient plan is to place the glass to be examined between two similar pieces of the standard glass, and place behind them a sheet of white paper illuminated by light from the source which will ultimately be employed in connexion with the glass in practice. Under these conditions any variation from the standard on the part of the middle glass, even though it be small, is rendered easily visible.

Determination of Maximum and Minimum Standards of Colouration for the Coloured Glasses commonly used in Signal Lights.—The intensity of the colouration, which it is convenient to adopt in a signal lamp, depends upon the intensity of the light employed, it being in general necessary to use weaker glasses according as the source is also weaker in intensity.

Red Glasses: A Standard of Minimum Colouration.—As the author has previously shown, it is not necessary to employ a very deep red glass in order to obtain a very clearly distinguishable red light at the minimum distance fixed by practical conditions at 100 metres. In reality, a pencil of coloured rays of light seems to behave somewhat like the rays passing through a tube

filled with feebly coloured solution: the greater the depth of the solution the greater the accentuation of the colour appears.

In the same way the greater the distance between very weakly tinted red glasses, illuminated from behind, and the observer, the more accentuated becomes their apparent colour. Hence, if one makes use of a very deeply coloured glass it becomes indistinguishable a short distance away, and therefore imperfectly fulfils its function as a signal lamp.

In defining the minimum standard of colouration for red glasses the following process has been employed: the flame of the signal lamp is adjusted to its normal intensity, and then, at intervals of two seconds, a series of five glasses, varying in colour from orange to a deep red, are in turn placed in front of the flame so as to be presented to the eye of an observer standing 100 metres away. The least deeply tinted glass which, at the prescribed distance, appears undeniably and distinctly red is then selected.

B. Standard of Maximum Colouration.—For the degree of maximum colouration we select a shade twice as deep as that specified for the minimum standard above. This is easily accomplished, by utilizing two sheets of the minimum standard glass placed one above the other in front of the illuminated white paper as previously described. This still allows sufficient light to pass to be available as signals intended to be seen at a distance of several kilometres.

Ordinary Green Glass. — Maximum and Minimum Standard of Colouration. —In defining the limiting standards in the case of glass of this colour, one proceeds in exactly the same manner as in the case of red glass.

Signal Green Glasses.—Maximum and Minimum Standards of Colouration.— Signal green glass is chiefly utilized in connexion with signals at sea. By daylight illumination the glass appears bluish, but assumes a greener tinge when illuminated by a yellowish source, such as a kerosene lamp. Weakly coloured signal green lights appear white when viewed at a distance under certain conditions. For this reason it seems desirable to fix a single standard colour for glasses of this character, which must not be departed from.

Blue Glasses.—One Single Standard. While in the nature of things absorbing a great deal of light, blue glass, still more than signal green, does not encourage any departure from a suitably specified standard. It also presents the drawback of appearing colourless at a distance if the glass is too weakly coloured. Therefore, it seems essential to select, by actual observation at a distance of 100 metres, the type of glass which gives an unmistakable blue colour, coupled with as little absorption of light as possible, and to adhere to this standard.

Certain blue glasses give a violet colouration in conjunction with yellowish light, and these should be rejected because they might easily lead to a mistaken interpretation of the signals for which they are intended.

Violet Glasses.—One Single Standard. —This colour is but little utilized for night signals, and the author has no knowledge of any variety of glass employed for this purpose except the blue cobalt. This produces an apparently violet colouration, with the yellow flames normally employed as signals. The selection of a standard for this glass would have to be carefully carried out, for the least variation in the intensity of colouration of the glass causes the light emitted to be dominated by the red rays which the glass also allows to pass, and this might lead to serious misunderstanding.

The author is convinced from a wide experience that, by proceeding in the exact manner which has been described in this article, to fix the limits of colouration of glasses intended to be used with night signals, it is possible, in certain cases, to at least double the effective utility of such signals without any additional expense.

These recommendations are the result of prolonged experiments on the subject, which, however, space does not allow him to describe in detail in the present article.

SPECIAL SECTION.

Illumination and the Architect.

THE study of illumination is of exceptional interest to the architect, for the decorative schemes planned by him, and the architectural features of both the interiors and exteriors of buildings for which he is responsible, can only be rendered visible to the onlooker by means of adequate illumination. If the illumination is insufficient or incorrectly distributed, the general effects which the architect intended to produce will inevitably be more or less interfered with.

In the same way the intentions of the architect often bear very definitely on the nature of the scheme of illumination which an engineer may be called upon to introduce into an interior. The amount of light required is very greatly dependent upon the nature of the general scheme of decoration employed, and the placing of the sources of light in the room may be very greatly facilitated or otherwise by the arrangements of mouldings, friezes, &c., which the architect has seen fit to adopt. Hence the most perfect system of illumination would seem to entail some degree of co-operation between the man who is responsible for the architectural features of a building and the man who is concerned in the illumination of it.

The services which the architect can render to the cause of illumination are undoubtedly very valuable. In the first place, the degree of daylight illumination in a room is almost entirely the result of his efforts, and it must not be forgotten that in the majority of cases the greater portion of the work carried out in a building is done under daylight illumination. Yet whether such illumination is satisfactory or no depends chiefly upon the location and extent of the window-space and the method of decoration utilized. If the walls and furniture of a room are dark in texture it is usually not an easy matter to secure that all portions of the room are provided with adequate illumination.

In many cases it will, of course, be admitted that it is not necessary to secure an equally high illumination in all portions of a room, but even in this case no little skill is necessary to secure that the light in a desired position is both sufficiently strong and comes from the correct direction. In other cases, a number of people are equally distributed over the floor space of a room, and all desire to be able to read or write with comfort. In this connexion we may mention the important question of schoolroom lighting. The recent experiments of Prof. Scott in America showed that in many cases the illumination in the portions of schoolrooms most remote from the windows was very far from being satisfactory, and it seems to be admitted that in this country likewise the conditions are not always all that could be desired. Architects may do most valuable work by drawing attention to such defects, and co-operating with those responsible for the provision of artificial lighting in schools in order to see that adequate arrangements are made in the future. In Germany and America co-operation of this description is already customary, a joint committee, composed of lighting engineers, architects, and oculists

having been formed with the object of designing the systems of daylight and artificial illumination in schools now being erected. And it seems possible that the defective conditions in schools, to which attention has recently been drawn by the publication of statistics referring to the eyesight of school children, would be found on examination to be at least equally prevalent in many factories, workshops, &c.

This, however, is only one of the aspects of illumination with which the architect is concerned, and in connexion with which he can do valuable work. There are many quite distinct objects which light is intended to accomplish, and the provision of adequate reading illumination is only one of these. As mentioned at the commencement of this article, light must also be regarded as often intended purely and simply to exhibit objects of decorative and artistic value—mouldings, friezes, and architectural features generally. In some cases this object has to be accomplished conjointly with the production of illumination for purely utilitarian purposes. In others the æsthetic may be said to be the predominant or even the exclusive aspect to be considered.

The nature of the contents of a room or building which we desire to exhibit must often influence both the quality and quantity of light desirable, quite apart from any conventional standard as to what constitutes a "good" illumination—by which is usually meant a good reading or writing illumination.

One cannot but feel that the lighting of many historic buildings and churches, &c., has often been carried out in a casual and unsatisfactory manner without receiving the care and study that such illumination demands.

In some cases the illumination has been quite insufficient to enable the true character of the building to be seen, while in others the illumination has been bright enough, certainly, but quite out of harmony with the surroundings.

Even in cases in which the illumination cannot be said to actually violate the dictates of good taste, one is often conscious that more might have been done to emphasize special features in the building. Architects themselves would doubtless be the first to acknowledge that the utilization of light for purely decorative purposes with the object, for instance, of creating certain play of light and shadow, and of stimulating the imagination of the observer, deserves far more study than the subject has received at present. We are constantly erecting buildings in our streets which, we consider, improve the appearance of our city by day, but are hardly visible by night. Something might doubtless be done to illuminate the exterior of such buildings in such a way as to produce a tasteful and artistic effect. Again the value of soft and diffusing sources of light as objects of decoration pure and simple certainly deserves more general appreciation.

There is also a wide field for the application of artistic principles to fixture design. The relation of these to their surroundings is certainly not as generally respected as the architect would desire, and it rests largely with him whether this point is sufficiently respected among engineers in the future. At present the difficulty is not that the latter are not anxious to learn what really constitutes æsthetic illumination, but that information on such points is not readily accessible or is presented in technical form not readily assimulated.

On all such questions as this the advice of the architect is valuable, and it is very desirable he should take an opportunity of putting his views on this question before those who are responsible for the illumination of public buildings. There has been a deplorable impression among both architects and engineers in the past that their views as regards questions of utility and artistic appearance were necessarily at variance. In reality the aims of engineer and architect are alike; both desire to produce a system of illumination best adapted for the purpose in view, but for want of the opportunity of discussing these questions each has occasionally failed to be sufficiently sympathetic with the objects with which the other is mainly concerned. Engineers have

naturally been chiefly impressed with questions of efficiency of light production, and have been very ready to condemn so-called artistic fixtures, or globes which they consider badly adapted to the purpose of efficient light distribution. At the same time it is to be feared that they themselves, in their zeal for producing systems of illumination which are efficient from the utilitarian point of view, have occasionally adopted methods which are open to objection on artistic grounds.

Why should it be regarded as impossible to devise illuminating apparatus which is itself pleasing to the eye, which is arranged so as to produce the æsthetic conditions demanded, and which, nevertheless, is scientifically designed to effect its purpose with a minimum expenditure of energy?

We have already suggested how valuable would be the co-operation of the architect in leading to a more general appreciation of what really constitutes artistic lighting. It is equally true that the architect would benefit by the co-operation of the engineer. The latter would be able to bring before him the very latest developments in the methods of illumination with which the architect naturally has not time to identify himself; he might even be able to suggest how a globe or fixture might, by a slight modification, fulfil its æsthetic purpose and yet be vastly improved as an efficient distributor of light.

It may fairly be urged, too, that the requirements of illumination from a physiological standpoint would in the long run be found to be in harmony with the principles of the æsthetic lighting. Methods of illumination which are trying to the eyes, bright "speckly" patterns and violent contrasts of light and darkness, are usually not only physiologically bad, but would probably be considered the reverse of pleasing from an artistic view. Our conceptions of what is beautiful are probably physiological and psychological in origin; anything which is distressing to either sense must tend to become inartistic.

In short, the requirements of good light from these three points of view, the utilitarian, physiological, and æsthetic, are not necessarily inartistic. In certain cases each of these aspects becomes the predominant one. The expert illuminating engineer of the future must be a man who is conversant with all three, and is able to judge the claims of each in an impartial manner. By the co-operation of those chiefly connected with one or other of these three aspects their relative importance in special cases will gradually come to be appreciated, and thus the impartial expert may eventually come into existence.

Electric Light as Related to Architecture.

By C. Howard Walker.

(From the Transactions of the Illuminating Engineering Society.)

In speaking about electric light as related to architecture, I have naturally to take the architect's point of view, that is to consider that when architecture is illuminated decoratively, it is not so much for the purpose of displaying the lamps as it is for the illumination of the architecture itself; which is a somewhat difficult problem, as our architecture is so diverse, and as most of it is far from being good. The illumination of architecture must be considered discriminatively. There are many buildings which would be very much better if they were not illuminated, and upon those buildings electric lamps may be placed, of which the effect is better than the architecture. There are buildings which have architectural merit, and in lighting those buildings, discrimination is necessary, and suppression of direct electrical effect is advisable if the building is to be shown at its best. I have seen buildings at night with electrical displays placed upon them which appeared better than they did by day, because of the ingenuity and the skill and the good taste of the electrician; and I have also seen buildings that were excellent in the daytime, but which lost all their merit at night, because the electrician had applied to them the same type of work he would have placed upon an inferior building. I suggest, therefore, that when a building is to be illuminated, you should ask yourselves as to the merit of that building, and if it is a thoroughly fine building architecturally, that you should suppress your electrical devices and your electrical effects *per se*, and apply electric lighting entirely toward illuminating the building so as to show it at its best at night, which means, that to a certain extent, you must adopt a day method of lighting. It is for this reason that I have divided the illuminating of the buildings, first, into different methods of lighting, and then have considered the application of these methods.

The factors which influence the electrical illumination of architecture can be readily analyzed; first, in regard to the character of the lighting; second, in regard to its position upon the buildings. The effects desired may be obtained by reflected light, the source of the light itself being concealed; by diffused light, shining through some translucent substance interposed between the light and the spectator, or by direct light, in which each source of light is undisguised.

In both direct and diffused lighting the effect is that of a series of luminous spots, each with or without a penumbra, which, by repetition, form lines, foci, and patterns. This type of lighting is the outlining of buildings by lamps, in much the same manner as a child draws with chalk on a slate. All light effects obtained by this method are independent of their background, except in so far as they follow its lines; as far as its masses, surfaces, and details are concerned, the lamps might as well be erected as a framework in the air. They are merely set pieces of permanent fireworks.

Diffused lighting through translucent material serves both to soften direct lighting, and also to afford a luminous background to inscriptions, devices, and other details, or to form conspicuous luminous areas.

Reflected lighting brings out the surfaces and details of a building in much the same way as does moonlight. As a matter of fact, all architecture is designed for effect by reflecting the light of the sun and, being so designed, it is but natural that it should appear at its best under artificial light when that light is reflected by the architecture. But the light reflected by architecture by day comes from one direction only, and produces shadows in one direction only, while that produced by artificial light must be received from several sources and directions. Artificially lighted architecture, therefore, depends for its effect more upon lighted areas than upon its shadows, these latter being constantly reduced by cross lights. The architectural skeleton, therefore, the cornices, beltcourses, columns, &c., are defined more by high lights than by heavy shadows, and these high lights should be more evident upon the projections than in the recesses. A

dark building with light trims is always more satisfactory than a light building with dark trims. The latter seems like a photographer's negative, and much of the electric lighting of buildings also has this effect.

The fact that a line of lamps at the top of a cornice is usually satisfactory, is not entirely due to the spots of light, but largely to the fact that they illumine a strong structural projection, and produce the high light where it was intended in the design of the building. And in most buildings the horizontal lines are the proper ones to accent, especially if direct lighting is to be used. The intensity of light is such, that each spot diminishes very slightly in luminosity by increase of distance. There is little or no additional atmospheric diminution between lamps at 50 feet distance and those at 200 feet distance. Consequently the whole tendency of direct lighting is to diminish the apparent distance, excepting when perspective convergence of lines is very definite.

This convergence is, of course, apparent in all horizontal lines of light on planes receding from the spectator. It is but little apparent in groups of vertical lines. Consequently, the outlining of vertical structure, excepting in isolated towers, tends to diminish the effect of space, and should be avoided.

This fact has been demonstrated in exposition work.

There should also exist in direct lighting a discriminating sense of which are the major or minor factors of a building, especially when arches occur. It is the constant practice to outline an arch, merely because it is an arch, regardless of its relation to the remainder of the lighting. When the arch is a continuously repeated factor, as in an arcade of considerable length, of at least seven or more arches, it becomes a major factor, and can be satisfactorily outlined; otherwise it is isolated, and of little value. This does not, of course, apply to large central portal arches.

The outlining of openings tends to nullify the proper effect of architecture. The penetrations of a building should be maintained, and the thickness of wall and the reveals shown by reflected light.

The general indications, therefore, for good electrical illumination of architecture are these: First, that such illumination is best obtained by reflected lighting; second, that when the direct lighting is associated with reflected lighting, as it needs must be, a new and entirely separate intent is introduced; *i.e.* that of making a design in light itself associated with the architecture, and indicating its structure, but not its masses. All devices of lights only are of value for their own intrinsic beauty alone, having nothing whatever to do with the architecture, excepting that they indicate axes or terminations.

As vertical lines of light tend to diminish effect of space, they should be avoided, and horizontal lines of light which assist the effect of perspective and space should be used. It is manifest that reflected lighting must be produced from sources of light at some little distance from the surfaces lighted, and some of the most successful illuminations of architecture have resulted from combinations of direct lighting in horizontal lines, and reflected light from standards or large lamps away from the building. Wall-brackets and lamps in ceilings of porticoes, &c., are always successful.

It is natural that there should be a desire for some coloured light, merely as an effect of colour. If this is used, the effect is merely spectacular. Foci of colour, or entire lines of colour, may occur, but white light tempered by ground glass is the most permanently pleasing. If colour is used, alterations of strong colour, such as red and blue, are not nearly as effective as alternate lamps of white and colour. Variations of candle-power in arrangement and grouping of lights afford opportunities for very pleasing effects.

For instance, the main factors of a building, the cornices and lintels, would have a higher candle-power than the candle-power of the small details. Very often I have seen this reversed, and the effect of the architecture thereby destroyed.

There is a constant demand for new effects, the fact being somewhat ignored that good taste would be the most novel incident which could occur, and that there is no definite formula for good taste. Careful experiment and a discriminating sense of the difference between the lighting, which is intended to enhance the effect of the architecture, and that which is spectacular with architecture as its background, and the power to combine the two is to be desired.

There is another thing to be considered and that is the connexion between one set or line of lamps and another, especially in direct lighting. Electricians are very prone to run along until they strike something which they cannot get over, and do not know how to get around, and there is a gap of darkness before another lighted place appears. Immediately the

continuity of the skeleton disappears, and the effect is of disjointed members.

The architect, as his name indicates, is the chief builder and constructor. His building should be solid, it ought to appear to have a strong structure, and it should be made in beautiful proportions. It is erected for daylight purposes. If it is successful at all, it should be best in daylight. The illumination which throws cross lights, and which has centres of reflection which grade into shadows, is a fairly low illumination; it is unsubstantial illumination; it begins to make architecture not so much solid as ephemeral. It has a beauty of its own; it is theatrical. The motif of reflected light from above, which has in it luminous deep shadows, is excellent lighting by night. It gives a new pleasure, and is perfectly consistent with any good architecture, but it is different from the daylight. The architect is designing for daylight, and if he cannot design a building that looks better for the time for which it is designed than it does when lighted in another manner, he has not succeeded, and that is what I meant when I said that a very large proportion of our buildings were not worthy of having light thrown on them. It would be a great deal better if the sun did not shine on them. Take the court-house in Boston for example; I have seen the court-house on moonlight nights when the series of great arches was very effective, and there is nothing finer than a great arcade, as the aqueducts which approach Rome testify, but our present court-house is so much superior by moonlight than daylight that you would not know it was the same building.

DISCUSSION.

PRESIDENT SHARP.—This paper comprises the two very important properties of being very instructive and very entertaining as well, and I am sure we feel indebted to the member who has presented it. This paper is now open for discussion. Is there any discussion?

DR. E. P. HYDE.—There is one question suggested by Mr. Walker's paper on which I wish he would give us an expression of opinion—Is the architectural beauty of most buildings the greatest by daylight illumination? In other words, even in the case of a building which is architecturally very fine, is it not possible to bring out the architectural beauty of the building by artificial means better than we can by natural illumination? Are there not certain limitations that the architect cannot get around?

MR. WALKER.—There ought not to be, but there sometimes are.

MR. CALVERT.—Do I understand Mr. Walker that in the outlining of the outside of a building all vertical lines should be omitted?

MR. WALKER.—That depends upon whether your building is isolated or not. I meant to have made that definite. If you are standing directly in front of a building, and that building is a unit, there is no reason why vertical lines should not be used; but when you wish the effect of a vista, as in exposition work, and there are a series of buildings down a vista, the effect of vertical lines, as I found by experience, tends to diminish apparent distances. There is no atmosphere to render electric lighting effective. I have never seen frosted lamps tried in that way. I should suppose they would be much better than clear lamps, but you can realize at the distance of 50 ft. or 100 ft. the comparative intensity of the direct light from lamps at 800 ft. distance is not appreciable.

MR. WILLCOX.—I ask Mr. Walker if he considers that as a general criticism of the modern practice, particularly in the West, of outlining buildings by lamps. We know it has grown to be the practice, to outline buildings with electric lamps, the verticals and horizontals, window tops and door tops, all over these buildings.

MR. WALKER.—The outlining of buildings with electric lights is exactly like a child drawing on a blackboard. The contrast between the lamps and the building is so great that you do not see the building—you see the lamps. If the building is bad I am glad to have the lamps there, but if the building is good I prefer to have it comparatively undisturbed by brilliant points of light. It is much better to use reflected light, with occasional points, where wanted, of direct light. The direct light is spectacular, and it might just as well, in most cases, be put up on a frame in the centre of Boston Common as far as it has to do with the buildings, but it is sometimes more effective than the building on which it is placed.

Artificial Illumination from the Architect's Standpoint

By Waldo S. Kellogg.

(From the *Transactions* of the Illuminating Engineering Society, March, 1906, No. 2.)

This paper will touch upon a few of the general features of interior illumination while attempting to outline the architect's interest and his relation to others interested in the same subject, but from a different standpoint.

The high intrinsic brilliancy of most lights is largely, I think, responsible for an immense part of the light usually wasted. In figuring on a high efficiency the maker forgets that the dazzling effect of an unshaded light so blinds the eye, that a much higher degree of illumination is required. In thus getting, for advertising purposes, a slightly higher theoretical efficiency, practical considerations are lost sight of. If the makers of lamps considered the best interests of the consumer, rather than the seller of current or gas, well-shaded lamps would be the rule, and not a special article supplied reluctantly at a price calculated to discourage their use.

The so-called 16 candle-power lamp has become the generally accepted lamp, but recently the tendency seems to be toward more powerful lamps, not because there is a demand for them, but by reason of improvement in lamp efficiency. It was remarked above that manufacturers catered to distributors of light, hence to induce them to take up their lamp, new units are made up using the former amount of gas or current, and a great noise is made about the intensity of illumination. If the public can get an innings it may pay to advertise. "We can give you the same light for half the money," instead of as now, "For the same money we can double your illumination."

There is no generally accepted standard lamp rating, except such as best suits the eccentric distribution of the lamp for which, at that moment, some manufacturer is claiming the merits of all other lamps besides other virtues. The candle is a reasonably satisfactory unit of measure, but the rating of lamps in candle-power should mean something and enable one to judge what the illuminating value really is. Spherical candle-power rating is a fair basis of comparison, and until the spherical rating is adopted no one, except he is able privately to ascertain the true rating, is prepared to say that a certain intensity of illumination can be obtained by using a given number of lamps of one kind or a different number of another kind. If without means to get data he must, to protect himself, put in outlets for two, and to be really safe, three times the number of lamps the manufacturer's rating in candle-power calls for, and the client is apt to complain of large lighting bills. It is in this necessity for protecting himself that the architect lays the foundation for the unpopularity of the light distributor.

In all cases a lamp should be so constructed as to harmonize with its architectural surroundings. In a carefully designed building the lamp, with as small a sacrifice of efficiency as possible, must conform to the architectural background. Thus, when a manufacturer professes to be unable to adopt a standard design to suit the architect's ideas, he must expect to be told that if such is the case the lamp will not be used, as considerations of efficiency are of less importance than the æsthetic ones.

The colour of any light plays a more important part than some manufacturers like to believe. Man has become so accustomed to the warm glow of candles or similar light that in domestic work he prefers a light of this colour, and a bluish white or greenish white light will be used only when a very strong light is needed. Women say that candle light adds to their natural attractiveness, and with them in opposition the sickly light is very heavily handicapped.

The architect is employed to make a structure both convenient and beautiful, and in doing this it is often necessary to sacrifice so-called practical considerations for others of an æsthetic nature naturally of great importance in the practice of a fine art.

DISCUSSION.

DR. EDWARD L. NICHOLS.—It is quite by accident that I happened upon your meeting to-night, but it was a very happy accident, and I take this opportunity of congratulating the new Society upon the attendance and the interest manifested in its objects.....

Although we have been using light since prehistoric times, is it not true that at the present time we are still guessing about it? The architect and the contractor—everybody pretty much—are still guessing about it, and yet it is an art which is capable of being reduced to computation, and which can be made as much a matter of precision as any of the other specifications with which engineers have to deal. I hope that this society will bring it about, or help to bring it about, that these things in the future shall be attended with greater and greater certainty. We must stop measuring candle-power and begin to measure the illuminating effects. We must educate the public so that they will not look at the lights, but will consider the advantage of the illumination of surrounding objects from these lights. Of course, these things have been more or less dimly understood, and occasionally the principles have been worked out with great success; but there is a great field in this for the education of the public, and also for the education of the engineer himself. I really think that the organization of this Illuminating Engineering Society is something which will be memorable; that it will take a leading place among scientific and technical bodies, and that it will be an important factor in the development of a very old and imperfect art into a very new and highly perfect art. Especially will this be the case if you can get the scientific, the technical, the architectural, and the æsthetic interests to join hands. I shall not say anything about the papers now, but I did want to bring this word of welcome to the new society, and to wish all its members high success in their undertaking.

Suggestions as to how the Architect and the Engineer can Combine.

BY PERCY J. WALDRAM, F.S.I., *Past Chairman J.I.E.*

(Paper read before the Junior Institution of Engineers, Feb. 12th, 1908.)

ALTHOUGH this paper deals with the question of co-operation between the architect and the engineer from a general point of view, and not exclusively from the point of view of artificial lighting, much of what Mr. Waldram has to say applies very closely to the possibility of co-operation between the architect and the illuminating engineer. The author begins by quoting from a previous paper on the subject in which the suggestion was made that "Engineers should not hesitate to seek the collaboration of architects whenever architectural skill was necessary with their work. Architects have the responsible control of a very large field of engineering work, and a still larger field of potential work now left untouched," and:—

"It is the imperative duty of Institutions, on both sides, having a proportion of younger members, to do all in their power to extend early and fruitful connexions."

These words were written exactly ten years ago. Yet the author fears that not much progress has been made since that date, and that continental and American practice is to-day far ahead of British in the facility with which each profession absorbs all that is best in the other. The author does not, however, mean to suggest that the engineering and architectural professions should amalgamate, but simply that each should seek the assistance and co-operation of the other. There are many highly specialized branches of work in which the special knowledge of engineers would be very valuable; for instance, in such matters as water supply, heating, artificial lighting, ventilation, and reinforced concrete construction, &c. In this connexion the architect is fully aware that his knowledge and experience is limited to ordinary expedients, and when special appliances are necessary would be willing to seek the expert in these matters.

One difficulty which faces any attempt at co-operation is the question of where the engineer's fees are to come from, and the author considers that it is partially this difficulty which has led the architect not unfrequently to rely on the technical advice of the manufacturing engineer alone. Yet the latter is frequently adverse to subordinating his designs and methods to the intentions of the architect, and grows accustomed to giving him whatever he has generally been accustomed to produce in ordinary practice, without due regard to æsthetic considerations. Thus arrives the unfortunate condition of affairs that even an experienced and broad-minded architect, who appreciates to the full the constant triumphs of the engineer, yet prefers to have as little to do with him as possible in his work. In this he is unduly prejudiced, but has a considerable amount of reason on his side.

"What architects really need is the work of engineers who, whilst skilful, experienced, and well abreast of the times, are neither biassed nor in a position tending to influence their work and their judgment in the commercial interests of their own pockets. Architects want men who are ready to undertake small work at correspondingly small fees, and who will be willing to frame and vary their designs to comply with the requirements of their buildings. There is plenty of work for such men if the architect only knew where to find them, and the need of their services is increasing every day."

Engineers are equally in need of the assistance of the architect, though the average manufacturing engineer, unfortunately, seldom appreciates the work of the architect to the same extent that the latter appreciates his. He is apt to consider the architect as devoted to old traditions and customs, not very practical in his methods, and, in short, the last man to whom an engineer would go for practical assistance. This view is really very wrong and quite unjust to any architect worthy of the name, for in many cases the special knowledge of the architect would not only lead to the æsthetic appearance of the building being more satisfactory, but also to a considerable reduction of costs.

In short: "The kind of architects whom engineers need are experienced, practical, up-to-date men possessed of a discriminating knowledge of materials and processes, ready to undertake small work, and who are, above all things, able to express their ideas of beauty (at least in utilitarian buildings) through the best adaptation of means to an end, rather than by the application of extraneous ornamentation."

Among the present difficulties in the way of co-operation the author mentions:

(*a*) The difficulty of finding the right man at the right fee;
(*b*) Professional prejudice;
(*c*) Custom.

The first is regarded by the author as most serious, and, in order to secure the right man, he advocates the collaboration of societies devoted to the engineering and architectural professions. As a means of providing the fees demanded by the specialist engineer, he mentions the possibility of setting aside a proportion of the cost of such items as reinforced concrete, electric light, special ventilation, &c., which are generally included in the contract, and on which a quantity surveyor generally, but not invariably, receives a certain percentage.

By drawing on funds of this nature, small as they are, the cost of employing the specialist engineer might frequently be met without encroaching on the well-earned fees of the architect.

[Space does not allow us to include also the interesting recent paper by W. Basset Jones before the Illuminating Engineering Society of New York dealing with this subject. With this paper, and the instructive discussion to which it gave rise, we mean to deal fully in a subsequent issue.]

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

The Legislation of Gas-Testing.

THE BRENTFORD GAS CO. FINED FOR DEFICIENT ILLUMINATING POWER.

(Abstracted from the *Journal of Gas-Lighting*, Jan. 28th, 1908.)

AN interesting illustration of the anomalies that are sometimes presented by the prescribed methods of gas-testing is furnished by a recent judgment against the Brentford Gas Co.

In accordance with the Brentford Gas Act of 1868, this company is legally bound to supply 14 candle-power gas, the gas being tested by means of an Argand burner having 15 holes and using a 7 in. chimney, and passing 5 cubic feet of gas per hour.

On behalf of the Chiswick Urban District Council it was stated that on two occasions—Oct. 10th, 1907, and Jan. 15th, 1908—the company failed to supply gas of the statutory illuminating power. On Oct. 10th the tests made by the Council showed that an illuminating power of 11·13 candles only was obtained, while on Jan. 15th the value was also only 11·24 candles. Under the same circumstances the tests carried out by the Company, however, gave values well over 14 candle-power.

This difference was ascribed to the fact that the standard burners used in the two cases, though complying with the description above, were not the same.

According to the view taken by the Council the Company were legally obliged to adhere to the burner which was presumably intended by the Act of 1868, namely, the Sugg-Letheby Argand burner. The Company, however, contended that it was absurd to ignore all the changes in the manufacture and use of gas since 1868, and to tie them down to an admittedly obsolete and defective type of burner. "The Brentford gas-burner was thoroughly efficient," but the Sugg-Letheby burner was a "poor thing."

The use of this burner instead of the former one actually made a difference of 3 candle-power to the illuminating value of the gas tested, and if the local authority were correct in insisting that the Sugg-Letheby burner ought to be used, the price of gas would have to be increased by 3*d.* per 1,000 feet. The object of the Brentford Gas Co. was to sell gas as cheaply as possible.

Eventually, however, the Bench decided in favour of the District Council, holding that the Act of 1868 prescribed the burner used by the Council, and imposed on the Company a penalty of 10*l.* on each summons, and 100 guineas costs.

In commenting on the case the *Journal of Gas-Lighting* remarks that the Brentford Co. are indirectly responsible for the present unsatisfactory and uncertain position, owing to their not having applied to the Board of Trade with a view to obtaining a more modern system of testing.

On the other hand, not much sympathy can be expressed with a decision based on such antiquated conditions. The exact legal aspect of the matter turns upon what was really in the minds of the authorities in 1868. The expressed opinion of Mr. W. H. Patterson, one of the gas referees at this date, seems to suggest that in 1868 there was really no "standard" burner, in the strict sense of the word, and it appears possible that it was a mere coincidence that in 1868 Mr. Sugg introduced his No. 1 Argand burner, a burner that, in scientific refinement, was preferable to its predecessors.

Modern Photometrical Appliances.

(From the *Elektrotechnische Zeitschrift.* We are indebted to the courtesy of Messrs. The Union Electric Co., Ltd., for the use of the blocks illustrating this interesting article. The completeness of the photometrical equipment of the laboratories described therein may come as a revelation to many of those engaged in the testing of arc-lights in this country).

At their meeting in Hamburg during the present year the German Institution of Electrical Engineers (Verband Deutscher Elektrotechniker) laid down regulations referring to photometry: conferences have also taken place between the delegates of the International Photometrical Commission, the Union of Electrical Generating Stations (Vereinigung der Elektricitätswerke), and the Institution of Gas-and-Hydraulic-Engineers (Verein der Gas und Wasserfachmänner), with the object of determining, if possible, standard methods of procedure in photometrical testing. It was therefore thought that a description of an up-to-date photometrical laboratory, such as that utilized by Messrs. Körting and Mathiesen for arc-light testing, might be of general interest.

Two special rooms are devoted to photometry. The first of these occupies 9 by 10 metres in ground space and is 6·3 metres high, the whole of the interior of the room being thoroughly coated with a dull-black varnish. The second occupies 6 by 10 metres in floor area, and is 5 metres high, and in this case the walls and ceiling are left white.

The blackened photometer-room (which is shown in Figs. 1 to 4) is devoted to general photometric measurements, to the study of polar curves of distribution of light, and, in the case of alternating current, also to the investigation of wave-forms of P.D. and current. Measurements of the colour-values of sources of light are also carried out in this room. The white photometer room (Fig. 5) serves mainly for the purpose of studying ground illumination with direct and inverted methods of illumination, and the performances of arc lights generally.

In the blackened room there exist three distinct photometric appliances, the oldest of which—a mirror "polar photometer"—is shown in Fig. 1. A fixed standard is attached to the table and carries at its upper extremity a horizontal axis, in front of which a stationary scale of angles is fixed. Two arms of equal length and each carrying a mirror are capable of rotating about this axis. Both mirrors are inclined to the axis at the same angle, and during rotation describe a circle at the mid point of which the lamp to be tested is placed, the light of the latter being screened in the direction of the axis referred to.

Both the arms carrying mirrors are displaced simultaneously through 5 degrees at a time, and the beam of light reflected from them at any particular angle is received on a photometric bench, which is to be seen on the left in Fig. 4. The intensity of this beam is compared with standardized glow lamps of 10, 16, and 25 H.K. respectively, by means of a Lummer-Brodhun photometer, the photometer being maintained stationary, while the observer adjusts the distance away of the glow lamp by utilizing a cord and pulley arrangement. The electrical measuring instruments are placed near the arc lamp, and this space is completely screened off except for the necessary aperture through which the beam of light from the arc is to pass. By means of this piece of apparatus polar curves of distribution of light can be obtained, due attention being paid to the co-efficient of reflection of the mirrors, but as a rule only lamps without globes are tested by this means.

A second appliance, for the purpose of obtaining polar curves is the "diagonal photometer" shown in Fig. 2. In the middle of the room are situated two vertical guide bars, between which the arc lamp to be tested is suspended and can be moved to and fro. The guide-bars are provided with graduation marks, corresponding to the position of the lamp. At right angles to these bars and running diagonally across the photometer room are placed four photometric benches which travel on fixed rails, and are all provided with Lummer-Brodhun photometers and calibrated comparison lamps. Measurements can then be made simultaneously by two or four observers in the following manner. The arc lamp and the photometric benches (at the zero point of which the photometer is

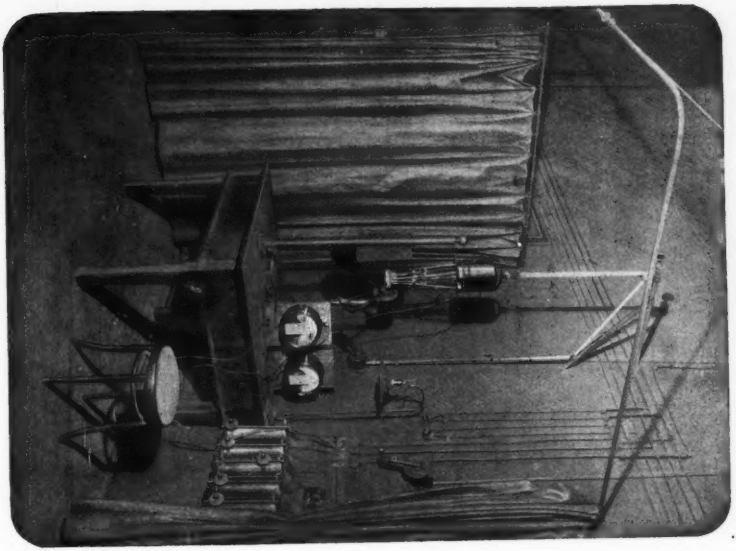


FIG. 1.—MIRROR "POLAR PHOTOMETER."

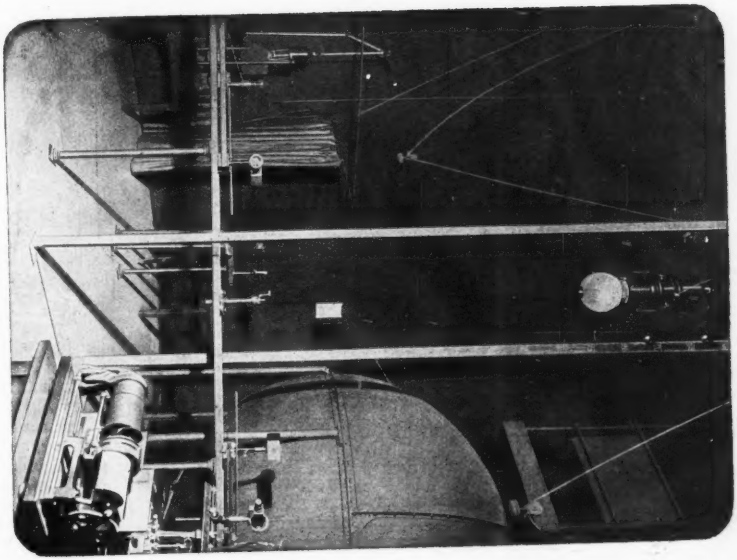


FIG. 2.—"DIAGONAL PHOTOMETER."

maintained) are adjusted to certain corresponding positions which have been calculated once and for all as being equivalent to certain angles of radiation to the horizontal on the part of the arc lamp under test. The photometer heads are then rotated through half this angle in the recognized way, and the observer obtains photometric balance by adjusting the distance of the comparison lamp. In this case also the electrical measuring instruments are situated in the screened room beside the mirror photometer, and are illuminated by a glow lamp.

The third photometric appliance consists of an Ulbricht globe photometer, 3 metres in diameter, which is used in combination with a Weber photometer (Fig. 3). The Ulbricht photometer enables the mean spherical or mean hemispherical candle-power to be obtained by a single measurement. Without entering into the theory of the instrument here, we content ourselves with describing a concrete instance of its application.

The globe is not divisible, but the interior is accessible by means of two openings at top and bottom respectively. By making use of the latter a man can work very comfortably in the interior of the globe—for the purpose of renewing the enamel, for instance. The lamp to be tested is lowered into the globe through the upper opening. A gallery is erected above the globe, which carries the necessary arrangements of suspension for the lamp and also the switchboard, series resistances, terminals, &c., and a movable table on which the electrical measuring instruments are erected. The suspending arrangements are so designed that an arc lamp can be withdrawn

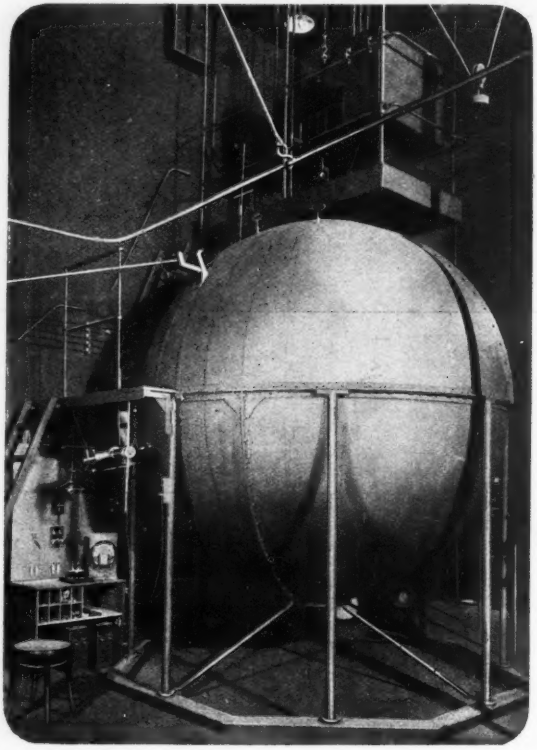


FIG. 3.—ULBRICHT GLOBE, WITH WEBER PHOTOMETER.

from the globe and then let down again without there being any reason to fear that its position has been altered. In the ordinary course of events one observer sits in this gallery, and it is his duty to attend to the arc lamps under test and read the instruments. At half the height of the globe a second gallery is erected. At this point there is a sight-hole, at the edge of the upper hemisphere, by the aid of which the position of lamps can be adjusted when it is desired to determine their mean lower hemispherical candle-power. Beneath this gallery is the window in the globe to

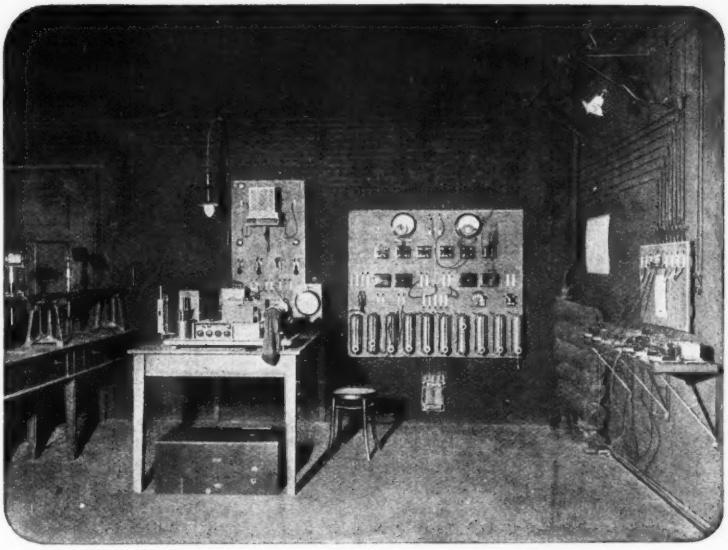


FIG. 4.—On the left is seen a photometric bench, in the centre an oscillograph, and on the right the distribution board.

which the Weber photometer is applied for the purpose of photometrical measurement. To the left of this is an arrangement for the purpose of calibrating the globe, together with the necessary switches, measuring instruments, &c., for the comparison lamps. These consist of three 100 H.K. calibrated glow lamps, the photometrical properties of which have been exactly determined.

All comparison lamps are fed by a battery of 60 accumulators the P.D. of which can be exactly regulated by a suitable adjustable resistance. The wiring of the circuits leading to the lamps is so contrived that exactly the same P.D. is utilized throughout the photometer room.

For the study of the colour differences between various illuminants, a special piece of apparatus is employed which enables the two sources to illuminate two adjacent screens of diffusing glass. The spectrophotometer, seen in the background of Fig. 2, is also utilized for this purpose.

As a rule the polar photometer shown in Fig. 1 is only used for naked lights, as the mirrors are hardly large enough to permit the study of lamps equipped with globes. In such a case the diagona photometer proves serviceable; with this instrument one can obtain the polar curve of a source equipped with any form of shade or reflector. Both these appliances are suitable for the determination of mean hemi- and mean spherical C.P., but the process necessitates the obtaining of a great number of readings, and is therefore both laborious and inconvenient when the source of light to be tested is an unsteady one. The process is also too lengthy to be conveniently applied to the general study of the influence of different factors on the M.S.C.P.

To all such purposes the Ulbricht globe, which permits measurements to be made

involving only a single reading, is specially adapted. With this instrument we are in a position to obtain reliable results in the case of even an unsteady and fluctuating source of light, and also to conduct researches on the actual influence of the alteration of this or that factor in connexion with the arc on the total light emitted.

For the purpose of studying the changes in the arc itself during the tests a projection arrangement is provided which throws an image of the arc on a screen situated behind the observer at the Weber photometer. This image is rendered visible to the observer by being reflected into a small mirror to the left of the photometer, so that he can follow all the variations in the structure of the arc while the experiments are in progress.

In order to utilize the globe for the measurement of mean hemispherical candle-power the centre of radiation of the lamp to be tested must be known. This last is determined on the diagonal photometer previously referred to by means of a vertically adjusted Lummer-Brodhun photometer-head.

Fig. 4 shows the arrangements utilized for the purpose of studying the wave-forms of current and P.D., which are in general obtained by means of an oscillograph. This apparatus serves for the study of the influence of the circuit on the nature of the current wave, observations of rectified alternating currents, and so forth. On the wall facing the table is erected a switchboard on which the necessary apparatus utilized in connexion with the oscillograph is mounted.

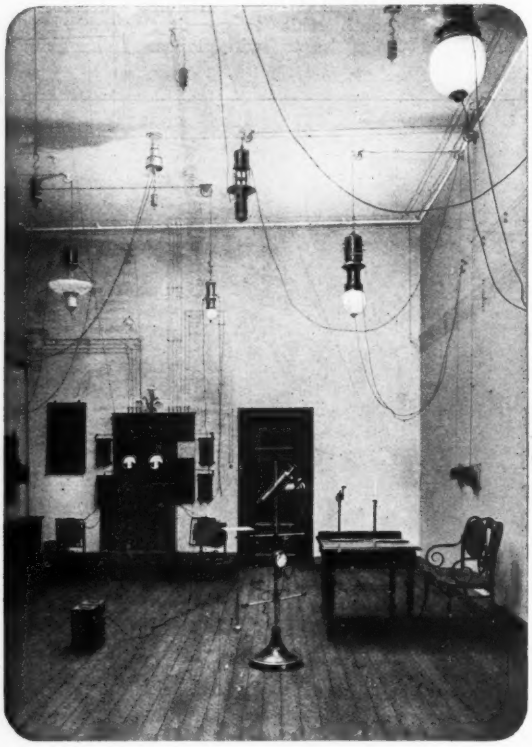


FIG. 5.—Measurements of Ground Illumination with Weber Photometer.

To the right of the table is seen the distribution board for the whole laboratory. The installation of the room is so contrived that an arc lamp can be used with any of the three photometrical arrangements described, with the same measuring instruments, and without it being necessary to disturb the circuits. In addition to this any rheostat or choking-coil can be switched into either of the circuits, and the wave-form of the current or P.D. of any lamp, in position for test, can be ascertained by the use of the oscillograph.

Finally attention must be drawn to the uses of the white photometer room shown in Fig. 5. The lamps to be studied are suspended near the ceiling of the room, and the illumination at a height of 1 meter above various points on the floor can be measured by means of a travelling Weber photometer. The comparison source in the Weber photometer consists of a small glow lamp which is fed by four portable accumulators. The photometer is calibrated by comparison with the Hefner lamp in the usual way. The influence of wall- and ceiling-reflection can also be studied. A shadow photometer is also provided by means of which two lamps having approximately the same candle-power can be compared.

The Influence of Atmospheric Pressure on the Sensitiveness of Selenium to Light.

THE possibility of using selenium as a measurer of light is attracting no little attention at the present time, and repeated efforts have been made to obtain the substance in a reliable state so as to avoid the various irregularities in its behaviour which have hitherto hindered its successful application to photometry.

The discussion which has recently centred round the behaviour of selenium in vacuo in various journals is, therefore, of considerable interest. Reference may first be made to a letter by Mr. W. J. Hammer (*Electrical Review*, N.Y., October 12th, 1907). In this letter Mr. Hammer expresses the conviction that a selenium cell, enclosed in a satisfactory vacuum, showed no "photoelectric effect," *i.e.*, did not give rise to an E.M.F. under the influence of light. The existence of such an E.M.F. must, presumably, be considered an obstacle to the utilization of the well-known alteration in resistance of sensitive selenium cells when acted upon by light. Mr. Hammer upheld the view that such photoelectric effects are only caused by impurities, especially moisture, occurring when the cell is not protected from the atmosphere; in short, cells enclosed in a vacuum are more constant in their behaviour and apparently better adapted to light measurements. Mr. Hammer has recently devised a new form of cells of this class (*Elec. World*, N.Y., Sept. 28th, 1907).

In a recent letter, however, Prof. Minchin (*Nature*, Dec. 26th, 1907) describes the results of an experiment which are quite contrary to the above supposition. In these experiments it was found that the resistance of a very sensitive cell, originally 61 million ohms, fell to only about 61 ohms when placed in an exhausted vessel, while the sensitiveness to light had disappeared. Three other cells behaved in the same way.

This letter called forth two further communications on the subject from Mr. R. J. Moss and Mr. Shelford Bidwell (*Nature*, Jan. 2nd, 1908). Mr. Shelford Bidwell suggested that the diminution in resistance referred to might be caused by a partial short circuit in the cell. Mr. Moss inquired if a mercury pump had been used in producing the vacuum surrounding the cell, because he had previously found that mercury readily combines with selenium. This might account for the change in its properties observed by Prof. Minchin.

In reply (*Nature*, Jan. 9th, 1908) Prof. Minchin states that the construction of the cells used rendered a short circuit out of the question. A mercury pump had, however, been used in the evacuation, and on repeating the experiments with another pump the resistance was found to increase slightly in vacuo, while the sensibility to light was retained.

Primary, Secondary, and Working Standards of Light.

By Edward P. Hyde.

Taken from *Transactions* of the Illuminating Engineering Society, October, 1907, "Convention Issue."

(*Continued from p.* 76.)

The situation with regard to secondary standards is quite different. It is generally conceded that the well-seasoned incandescent lamp meets every requirement of a secondary standard of light. The objection that is occasionally raised, that it changes with the time of burning, is not, in my opinion, as important as the changes which seem to take place at times when the lamp is stored away. A four-watts-per-candle lamp, if properly seasoned, will not change appreciably, *i.e.*, more than two or three parts in a thousand in fifty or seventy-five hours continuous burning. Since it only requires several minutes to measure an incandescent lamp, the standard lamp could be measured 500 or 1,000 times before it would change appreciably in intensity. Since at the Bureau of Standards there are incandescent lamp secondary standards that are only used once or twice a year, it is evident that if only the change in candle-power due to burning is to be reckoned with, the unit, in terms of which the secondary standards are expressed, could be maintained constant to within two or three parts in 1,000 for several hundred years.

On the other hand there seem to be much larger changes in the lamps from time to time while the lamps are not burning. Occasionally a lamp developes a bad vacuum; at other times, a change in resistance is noticed, indicating probably an altered contact resistance between the filament and the leading-in wires. But apart from these changes in candle-power, which are accompanied by changes in the electrical properties of the lamps, and which can probably be explained, there are apparent changes in intensity which are just over the limit of observational error, and for which we can offer no explanation. In determining the relative values of a number of incandescent lamps that have been intercompared before, one of the lamps may seem to be high or low in intensity, with respect to the mean of the remaining lamps, by a $\frac{1}{2}$ per cent. or more. I do not mean that a single observer with one set of readings finds the lamp off by that amount—observational error might possibly account for that; but the mean of a number of sets by one observer agrees with the mean of a number of sets by another observer, in giving to that lamp a value somewhat different from that which it previously had. In another set of measurements, some time later, the lamp may come back to its original value.

Whether these apparent changes are due to slight differences in the condition of measurement at different times, or whether they are real changes in the lamps, it would be premature to say at present. They are small, however, and if a number of lamps are used, the mean value should remain sensibly constant over a long period.

The well-seasoned incandescent lamp is also an entirely satisfactory working standard in the photometry of electric lamps, but it is not suitable for use in gas photometry. It requires electric power to operate it and electrical measuring instruments to control it, and these are usually not available, particularly in small gas plants. But apart from its inconvenience, it is unsatisfactory. The intensity of a gas flame is a function of the atmospheric conditions, and it would not be practicable to correct all measurements to standard conditions, as that would involve determinations not only of water vapour and carbon dioxide, but also of the proportion of oxygen present in the atmosphere. In supplying gas, however, it is desirable for the manufacturer to state that the candle-power of the gas furnished would be up to the requirement, under normal atmospheric conditions. The way in which to determine this, without actually making the corrections, is to have as a working standard a lamp that is affected by the atmospheric conditions in the same way and to the same amount as the gas under test. If the intensity of the standard lamp under normal conditions is known, the candle-power of the gas under normal conditions is obtained immediately, by

direct comparison with the standard lamp, independent of the atmospheric condition of the photometer room, provided it is uniform throughout the room.

The consensus of opinion among gas engineers is certainly that the working standard for gas photometry should be a flame standard. There seems to be less unanimity, however, in regard to what flame standard should be used. Candles are still used to some extent in the United States and abroad, but recently there has been considerable advancement, both in this country and in England, in the adoption of the Harcourt 10-candle-power pentane lamp. In Germany the Hefner lamp is used now to a great extent in gas photometry, I believe, and in France the Carcel lamp continues to be used almost exclusively. But although flame standards have been, and still are, used in gas photometry, I do not know of any investigation of the relative influence of atmospheric changes on the gas and the standard lamp. It is scarcely justifiable to assume that the coefficients are the same for two such flames as the pentane flame and the gas flame, which are controlled in entirely different ways. The pentane lamp is adjusted for flame height, whereas in much of the gaswork the flame of the bat-wing burner is adjusted to a definite rate of consumption of gas by weight. Recently, in co-operation with the United Gas Improvement Company of Philadelphia, the Bureau of Standards made some experiments along this line in one of the company's gas-testing photometer rooms in Philadelphia. Although these preliminary experiments were not carried far enough to warrant any very definite conclusions, they indicated that the two flames, the pentane and the gas, are affected in the same way, to approximately the same extent, by changes in the atmosphere. Since differences of 8 or 10 per cent. in the intensity of the standard lamp may readily occur under normal working conditions, it is evident that if results of any accuracy are sought, it is not sufficient that the atmospheric conditions affect the standard flame and the gas flame in the same direction; the coefficients of change for the two should be very nearly the same.

Another interesting fact in connexion with the working standards in gas photometry is that, with the possible exception of the Carcel lamp, which, I believe, has been calibrated in terms of the Violle standard, all of the lamps used as working standards are at the same time primary standards. In the photometry of electric lamps, the seasoned incandescent lamp soon came to be used as the working standard, since the primary flame standards were not convenient. But in the photometry of gas, since a flame standard was desired, the primary standards came to be used as the working standards. Although this is a logical result, it is questionable whether it is the most satisfactory one.

Is it not possible that a cheap and portable lamp, which would remain constant in intensity after having been calibrated, might be found which would be more convenient and more easily manipulated than the Harcourt pentane lamp, for example? It does not follow that the lamp which best satisfies the requirements of both a primary and a working standard will satisfy the requirements of a working standard alone better than any other lamp. In other words, the lamp which is best with respect to both constancy and reproducibility need not be the most constant lamp, if reproducibility is eliminated. With authoritative testing laboratories available, where secondary standards are maintained, it is no longer necessary that the primary standards should be used in industrial photometry.

I have no such lamp to suggest as a working standard for gas, and it is possible that none can be found, but I think it is well to divorce the functions of the two kinds of standards. Reproducibility is the chief requirement for a primary standard, and constancy with burning is only a convenience. With the working standard, reproducibility is of no consequence; the lamp, however, should remain constant while burning, thus maintaining the candle-power assigned to it on calibration. If the lamp which is the most reproducible is the most constant and convenient, then use it as a working standard, but do not confine the search for a working standard to those lamps which are reproducible.

The use of a primary standard as a working standard may, however, lead to a confusion of units between the gas and electric industries. This is exemplified by the situation in our own country at present. Both in the photometry of gas and of electric lamps the intention was to use the British parliamentary candle. The American Institute of Electrical Engineers recommended obtaining the candle through the hefner by the use of the ratio one hefner equals 0·88 candle, which was supposed to be the mean value of the best determinations of that ratio In gas photometry the sperm candle, or, more generally in recent years, the Harcourt pentane lamp, has been used.

It is definitely known now that the candle obtained through the pentane lamp does not bear to the hefner candle the ratio of 1 to 0·88. From comparisons through electric lamps measured at the National Physical Laboratory in England and at the Physikalische-Technische-Reichsanstalt in Germany, the above ratio is found to be in error by 2 per cent. From direct comparisons of Hefner and Harcourt pentane lamps the ratio appears to be in error by 4 or 5 per cent. If now both the gas and electric lighting industries adopted the same unit, which could be maintained at a national laboratory, and in terms of which working standards for both gas and electric lamps could be calibrated, "candle-power" would have a single significance throughout the entire country.

The final step would be to agree with other civilized countries on the value of the unit adopted, so that we might have in photometry, as in most other branches of physical science, an international unit. Although the German unit is so different from the others as to offer considerable difficulty to the realization of this plan, the units of England, France, and the United States are sufficiently close to warrant a compromise. This compromise would not entail the abolishment of the present standards; it would merely necessitate assigning to the standards different numerical values. Thus the Carcel would no longer be 9·6 bougies décimales, but probably 9·5 or 9·4 international candles. Each country could maintain the unit through whatever standards it chose, primary or secondary, but by frequent intercomparisons among the various countries, the unit would be maintained. Let the search for a suitable primary standard be continued, and may the time soon come when there shall not only be an international unit, but an international standard, which shall take rank with the other international standards of modern science.

DISCUSSION.

(Slightly abridged.)

PRESIDENT SHARP.—The paper by Dr. Hyde is of unusual importance, in that it recommends the adoption of an international unit of light as independent of the standard. This paper is now open for discussion.

DR. LOUIS BELL, Boston.—I am much interested in Dr. Hyde's very able discussion of this troublesome question of standards. The work of this Society lends particular importance to work of this kind. The work of this Society is more difficult from a technical standpoint than that of any other scientific body with which I am connected, chiefly because we have no standards. We have an art without any standards of measurement, and, moreover, we are in a greater danger than any other body with which I am acquainted of falling apart from a lack of these standards of measurement, because we lack definite specifications for methods of reaching these standards, and we run greater risks of apparent inaccuracy than any other class of engineers with which I am connected. That is particularly true in the measurement of illumination—measurement of intensity is bad enough, but measurement of illumination is tenfold worse. It has nearly, in fact, tenfold the probability of possible error.

It seems to me that Dr. Hyde's suggestion as to the final step to take is really the preliminary step to which all our energies should be centred—towards getting an international standard of light to which we can make reference through any system of working standards we please, and which would be one and the same in all civilized countries. That was the preliminary step which had to be taken before we got our electrical measurements and electrical nomenclature in anything like systematic form. We tumbled around for years with two or three standards of volts and resistances, and when I began to study electricity the ampere was known as the Weber, a name which now means something very different. This Society, with its international membership and its catholicity of interests, representing all branches of engineering which have to do with light and illumination, is in better shape than any society has been before to deal with the international side of the question through the co-operation of our foreign confrères.

The best energy of the Society should be turned toward getting some sort of international convention as to a uniform standard of light and intensity, and upon which we can base a systematic treatment of derived units. It is the international feature of the work which appeals to me particularly, because, once given a definite international standard, so that

we are all talking about the same thing, it will be comparatively easy to settle down upon some definite illumination photometers which will lead to less devious and wild results than are now obtainable.

PRESTON S. MILLAR, New York.—I am very glad to learn Dr. Hyde's high appreciation of the excellence of the incandescent electric lamp as a secondary standard of light. Probably a concrete instance of its reliability may be of interest at this time. I think it was in 1889 that a group of incandescent electric lamps was standardized at the German Reichsanstalt against the Hefner lamp. These lamps were secured by the General Electric Company, and, I believe, are still in their possession. In 1896 we, at the Electrical Testing Laboratories, were permitted to make copies of those lamps. From that time we have endeavoured to maintain that standard. Recent comparisons with the Reichsanstalt indicated that the standard has not varied, since that time, by as much as 1 per cent., and probably by not more than $\frac{1}{2}$ per cent.

When the National Bureau of Standards very properly took up this problem, a few years ago, we were very much gratified to learn that the standard which they had decided upon, after studying the situation carefully, was, so far as could be determined, in absolute accord with that which we had endeavoured to maintain. So, at the present time, electric lighting in this country is based, so far as the candle-power unit is concerned, on incandescent lamps which were standardized in 1889, and which to-day we believe have not changed in value, except in individual cases where lamps have altered materially for certain obvious reasons.

I think there is something to be said regarding the use of the flame standards in gas photometry, particularly that of mantle burners. It is true that it is the consensus of opinion among gas engineers that the pentane lamp is the most suitable standard, but is it not also true that they believe this because they have never given a fair trial to the incandescent electric lamp? I believe, from personal experience, that the incandescent electric lamp merits such a trial, and I think the conviction is growing among gas engineers that such is the case.

A. E. FORSTALL, New York.—I think that Mr. Millar is a little mistaken as to the reason for the predilection of gas engineers for the flame standard for photometric purposes. I think Dr. Hyde expresses the real reason quite fully in his paper. I know in discussions which have taken place on photometric standards at gas association meetings, that has been the point brought out most frankly as the reason for preferring a flame standard, even by the people who use an electrical standard as a working standard for some of their work. If you are going to be tied by law to a definite illuminating value for your gas, under penalty of a fine if the photometric test does not come up to that standard, you certainly should not be subjected to a fine because the atmospheric conditions affect your flame and do not affect the standard, and therefore it seems to me it is a logical necessity that the standard used for testing gas, or testing any other flame, should be a flame standard which will be affected by atmospheric conditions to the same extent as the flame under test.

There is a point in Dr. Hyde's paper that I am not certain I understand. He says: "It is definitely known now that the candle obtained through the pentane lamp does not bear to the Hefner candle the ratio of one to 0·88." I had never known that in the United States there was a candle obtained through the pentane lamp. If I am correct, the practice in Great Britain is to consider that every pentane lamp gives a light of exactly 10 standard candles; but as far as I am acquainted with the practice in the United States, each lamp is separately calibrated by a number of tests against standard candles, and its value, as thus determined, is used when it is used as standard; in fact, in the United States the pentane lamp is not really a primary standard, but a working standard.

DR. HYDE.—The statement in my paper has significance only in reference to the use of the pentane lamp as a primary standard of light. At the National Physical Laboratory, which is supposed to maintain the authoritative standards for England, they take as their standard of candle-power the intensity of the pentane lamp in their possession which they define to be 10 candles. It is usually assumed that all pentane lamps, if made according to specifications, would have the same intensity, and, if I am correctly informed, the intention of the practice in this country in the use of the pentane lamp is to reproduce the same unit of candle-power as that used in England. As stated in my paper, every recent determination has shown the ratio of the Hefner unit to this English parliamentary candle to be greater than 0·88, the value commonly accepted from earlier determinations, and expressing

the ratio of the Hefner to the candle unit used in the photometry of electric lamps in this country.

T. J. Little, Jr., Gloucester, N.J.—We have a number of organizations in this country, some gas and some electric, and inasmuch as the electrical organizations will probably favour the electrical standards of the present day, and as the gas organizations would in the same way favour the standards they are now using, and realizing that the adoption of Dr. Hyde's ideals of standardization of the unit of light would be rather difficult, and inasmuch as this Society is not affiliated with either one directly, and is supposed to be for both or all of the various lighting systems, it seems to me that this would be the logical organization to push the scheme suggested. I should think it would be in order to have a committee take the suggestions, in whole or in part, which have been presented in Dr. Hyde's paper, and try in some way to propagate the idea, and bring the matter forcibly to the attention of the two great forces of the country—the electric and the gas organizations. Dr. Bell calls my attention to the International Photometrical Commission, but quite irrespective of this commission, it seems to me that this is the logical society to exploit the scheme.

C. O. Bond, Philadelphia.—There are two points in connexion with the paper to which I desire to call attention. One is that at the present time a meeting of the International Photometrical Commission is being held at Zurich, and it is discussing this very question. Three sub-committees — the English, German, and French—have worked out the ratios existing between the values of the respective countries, and the report of these three sub-committees will be embodied in a common report. Any action which they may take will be taken very shortly probably. Would it not be possible for the Committee on Nomenclature and Standards of this organization to keep in touch with this International Incandescent Photometric Commission to act in unison with it?

President Sharp.—If I may be allowed, I would like to call attention to two or three things in this paper. I think we should ponder deeply on the statement on the first page that the eye is made the scapegoat for faulty methods or incorrect measurements. I think that this is too often the case. I should like to know from a practical incandescent lamp manufacturer, such as I know is present, whether it would not be practicable—this is wholly hypothetical—in case all of our primary and secondary standards were lost, for a lamp manufacturer to reproduce our present standard by the manufacture of a large number of incandescent lamps, computing as the manufacturers do, what the candle-power should be beforehand, and averaging up the actual candle-power of the whole lot. Would he not come very close to our present standard?

I would call attention to the fact that nothing is said in this paper regarding the photometry of the incandescent mantle burner, and proper standards for use in that connexion. That is an important field, and should be gone into. I raise the question whether it is not probable that lamps of the same temperature are very similarly affected by humidity conditions. I also call attention to the lamp which the last speaker referred to, Dr. Elliott's lamp, which has certain merits as a working standard for gas photometry, such as Dr. Hyde proposes. I will call on Dr. Hyde to close the discussion.

Dr. Edward P. Hyde.—It seems to me the subject has been threshed so thoroughly now, that there is very little for me to say in closing the discussion. I do want to endorse heartily what Dr. Bell said, and what Mr. Litle and several of the other members referred to in their remarks, in regard to some possible action along this line. I did not describe the situation in the paper, because I thought that the members of the Society understood it perfectly well. It seems to me that there is no other association in this country or abroad better fitted to push this question of an international unit than the Illuminating Engineering Society, and I would be very glad if this Society would take the initiative in this matter. It will be a slow process, naturally. We probably cannot reach an agreement in two or three years; but if we are working for the right end we ought to be satisfied. The longer we delay starting, however, the more difficult will the problem become, as the methods of photometry are becoming more accurate, and the ratios of the different standards are becoming more definitely determined every year. If we want to get this international unit, the thing to do is to strike right now while the iron is hot.

A New Process for obtaining Polar Curves of Distribution of Light of Artificial Illuminants.

By W. Voege.

(From the *Electrotechnische Zeitschrift*. January 16th, 1908.)

During the last few years successful efforts have been made to devise apparatus enabling the mean-spherical and mean-hemispherical candle-power from sources of light to be determined by a single measurement. In this connexion mention may be made of the Ulbricht globe photometer and the Matthews integrating photometer. These photometers, however, do not enable us to investigate the polar curves of light distribution of the sources under test. Yet nowadays it is very essential that this distribution should be studied. Our artificial lights are now so varied. We may wish, for instance, to compare the merits of arc lamps with vertical and inclined carbons, glow-lamps with filaments of various shapes, different types of diffusing globes, &c. The process of obtaining these curves by photometrical measurements at various angles to the horizontal is an extremely tedious one, and, in the case of lamps which are inclined to burn unsteadily, is also far from accurate.

The process would be greatly facilitated if photometrical measurements could be replaced by observations of the deflections of a galvanometer. Selenium naturally occurs to our minds in this connexion. We may, for instance, make use of the alteration in resistance of a selenium cell attached to an arm rotating about the source of light under test. The author has made many researches on the value of selenium from this point of view, but without really satisfactory results. The sensitiveness of the selenium cell is certainly ample, but the inertia, even in the case of the latest forms, is very considerable. The variation in resistance caused by a given intensity of illumination, is affected by the duration of exposure, and the time which must elapse before a constant state is attained is very uncertain. It is also unfortunate that the alteration in resistance of the selenium cell is not directly proportional to the intensity of the illumination. One never knows whether gradual changes in the condition of the selenium cell may not have taken place. This necessitates occasional recalibration, and—owing to the peculiarity of selenium referred to above—calibration over the whole scale.

On this ground the author has been obliged to abandon the use of selenium for obtaining curves of light distribution.

On the other hand he has succeeded in attaining his aim by utilizing the thermopile. The thermopile naturally does not react to visible rays alone, but is affected by the entire spectrum, by the radiating body, and mainly by the invisible heat rays. These rays, therefore, in the author's apparatus, are absorbed by fixed slips of clear glass, which are placed in front of the face of the thermopile.

The thermopile naturally cannot be utilized for absolute measurement of light, but, on the other hand, is well adapted for the comparison of the radiation in different directions of the same source where the ratio visible to total radiation is the same for all portions of the incandescent material. This is true in the case of an electric incandescent lamp, the filament of which is in the radiating condition throughout its entire length. Precautions must, of course, be taken to secure that the distance of the thermopile from such a lamp is so great that the dimensions of the filament can be neglected in comparison.

As the E.M.F. of the thermopile is directly proportional to the intensity of the radiation striking it, we need only observe the deflections of a galvanometer in order to obtain a polar curve, which closely resembles the usual curve of distribution of light. If we then obtain the candle-power in any specified direction by a photometrical method, we can multiply by a suitable factor and express the curve in candle-power throughout.

Whether this process is equally applicable in the case of arc lamps is not so certain. In the case of flame arcs, for instance, the radiation of heat is effected mainly by the glowing tips of the carbons, while the main source of light, on the other hand, is the luminescent vapour. We might, therefore, obtain a different curve by this process from that obtained by a purely photometrical method. By

taking the following precautions, however, the author believes that he has succeeded in rendering the process of practical application to arc lamps :—

1. In the case of arc lamps a piece of green glass, as well as the clear glasses previously mentioned, is placed in front of the face of the thermopile. This glass absorbs the red rays to a great extent, and so reduces any error introduced thereby to a minimum. The sensitiveness of the thermopile is naturally reduced, but still suffices. The author in his experiments used coloured glass about the thickness of 3 millimetres, and green glass 1·5 millimetres thick.

2. The thermopile is provided with a collector which concentrates the rays given out in different directions from the source over a certain solid angle on the face of the thermopile. We thus measure the mean of the radiation coming from different points in the arc itself or the globe surrounding it, and collected in this way, just as under practical conditions. For, in practice, an extended surface is illuminated by the rays coming from all the various points in the radiating body.

The results of a large number of experiments have convinced the author that a correct conception of the distribution of light from an arc lamp is obtained by this means, especially when the lamp is surrounded by a globe. In doubtful cases we can easily check the results by observing whether the distribution curve obtained is the same when obtained, first with red glass, and secondly with green glass. Under these conditions both curves should agree, and this was invariably the case during the author's experiments. The following table shows the results of a recent test on this point :—

Angle of inclination to vertical.	Green Glass a_{gr}	Red Glass a_r	$\frac{a_r}{a_{gr}}$
0	56	66	1·18
10	74	83	1·12
20	74·5	85·5	1·15
30	71	87	1·22
40	71·5	86	1·20
50	69·5	85	1·22
60	66·5	78	1·17
70	64·5	71·5	1·12
80	49	62·5	1·26
90	16	46	2·88 (?)

It will be seen that the ratio $\frac{a_r}{a_{gr}}$ does not differ materially throughout, if we bear in mind the irregularities necessarily introduced by the regulation of the arc itself. The discrepancy occurring at an angle of 90 degrees is probably to be attributed entirely to this cause.

By this process distribution curves can be simply and easily obtained in a few minutes. By varying the length of the arm carrying the thermopile, or the thickness of the glasses screening the face of it, the same arrangements can be applied to the study of arc lamps and also glow lamps, which are relatively weak in candle-power. In the author's experiments a Rubens thermopile and a Siemens and Halske galvanometer of 30 ohms resistance were employed, and the distance of the scale from the galvanometer was 5 metres. Under these conditions a deflection of up to 1½ metres was obtainable. The length of the arm carrying the thermopile was 40 to 60 centimetres in the case of glow-lamps, and 80 to 100 in the case of arc lamps. The readings were very steady, any irregularities due to draughts being avoided by the glass screen in front of the face of the thermopile. A constant and steady deflection was reached in 20 seconds ; the variation in zero in the course of the experiment did not exceed 2 to 3 millimetres, and can therefore be ignored. In Fig. 1, one of the curves of distribution of light obtained by this means is represented.

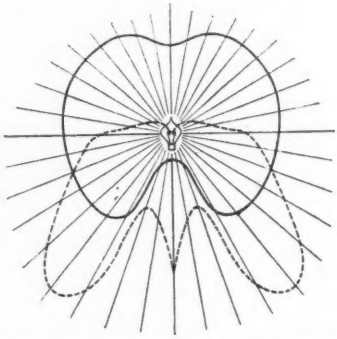


Fig. 1.—Carbon Filament Glow Lamp.
—— Clear glass bulb.
----- Upper half of bulb silvered over.

This refers to a carbon filament glow-lamp. The author, however, also gives the results of testing Tantalum, arc, and incandescent gas lamps by his method.

The process can be further simplified by making such arrangements that a spot of light from the reflecting galvanometer automatically traces out a polar curve of light distribution. This is

effected by enclosing a disc of sensitive paper in a light-tight box, a slit only being provided through which can pass the beam of light from the mirror galvanometer. The sensitive screen is fixed to the arm carrying the thermopile, and rotates about the same axis as the latter, as it is adjusted to its successive positions. The spot of light meanwhile travels diagonally across the disc, and its ultimate position, corresponding to each position of the arm, traces out the curve.

The arrangement is shown in Fig. 2, where s is the sensitive screen, k the light-tight box enclosing it, and r the rotating tube to which the arm a is attached. If desirable, the source of light under test can furnish the light required for the mirror galvanometer, as shown in the diagram.

The arrangements just described can also be conveniently utilized to register the fluctuations in candle-power of the source of light tested. For this purpose a spot of light is caused to fall upon a sheet of sensitive paper stretched on a drum rotated by clockwork at a uniform and known rate. Three of the records obtained by the author in this way are shown in Figs. 3, 4, and 5. Of special interest is Fig. 3, in which the variation in candle-power of a glow-lamp running on the Hamburg electrical supply mains is represented. The two gaps a to

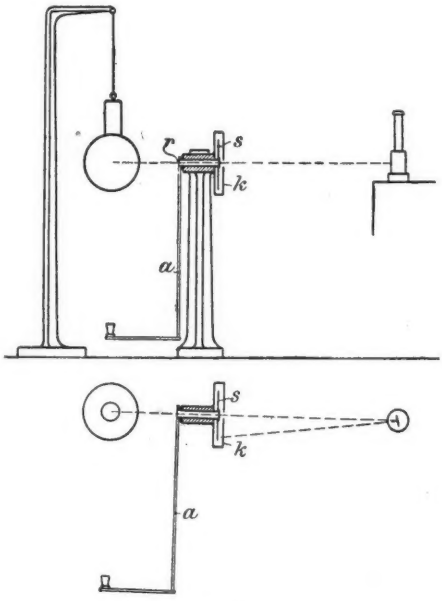


FIG. 2.

"s" Sensitive screen, "k" light-tight box.
"r" Rotating tube to which the arm carrying thermopile, is attached.
"a" Arm carrying thermopile.

b are caused by the momentary fall in P.D., caused by switching a large induction coil on to the lighting mains. The remaining Figs. 4 and 5 represent the performances of two enclosed arc lamps which were provided with opal globes, and supplied from a battery of accumulators producing a very steady pressure.

Fig. 4 shows the working of one of the older type of Lilliput lamps, and Fig. 5 the improved regulation of a more recent efficient enclosed arc lamp by the same firm.

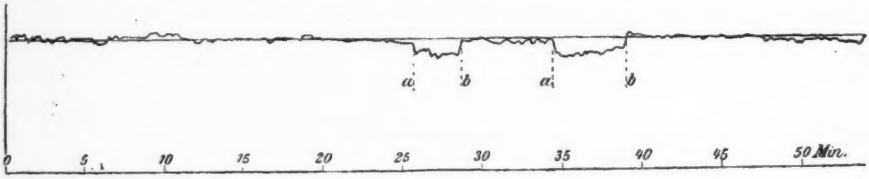


FIG. 3.

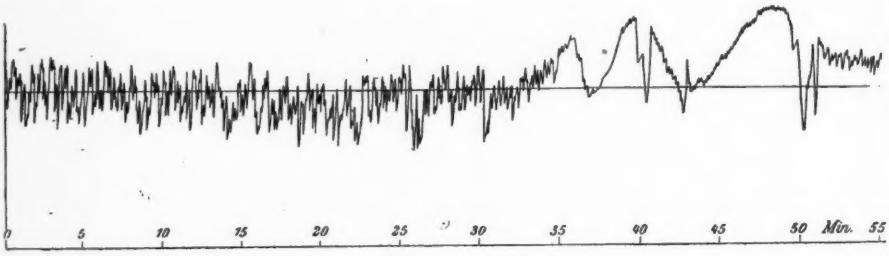


FIG. 4.

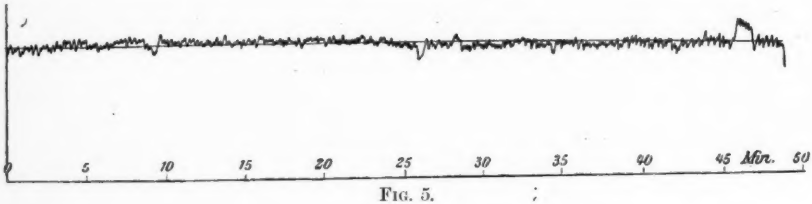


FIG. 5.

Some Aspects of the Metallic Filament Lamp Situation.

By H. M. Hobart.

(Abstracted from the *Times* Eng. Supplement, Feb. 5th, 1908.)

The term "metallic filament lamp" is understood to refer to lamps consuming about 1·2 watt per candle-power, with a life of about 1,000 hours. The writer, however, thinks that in spite of the enthusiasm naturally aroused by their high efficiency, the drawbacks of metallic lamps, as at present utilized, are not sufficiently realized. The use of such lamps on 200 volt circuits often means using more candle-power than is actually necessary, with a corresponding loss in economy. The greater concentration of the light in single high candle-power units is also a drawback. It is better to use five 10 candle-power lamps than one 50 candle-power lamp as regards distribution of light.

How, therefore, are the desired conditions to be obtained ?

The author advocates the use of a static transformer, and the adoption of alternating pressures of say 2,200 volts on the part of the Electrical Supply Co., the pressure being reduced to about 25 volts at the consumer's premises by means of a static transformer.

In this way, great economies can doubtless be effected, but, naturally, each case must be considered on its merits.

The author mentions the impression that some engineers, taking a short-sighted view of the loss in revenue which would follow the rapid introduction of efficient metallic lamps, are opposed to encouraging their immediate adoption. In reality, however, the use of these lamps would ultimately enable electrical supply companies to compete more effectively with gas, and present such a marked development in electric lighting as to justify fundamental changes in the nature of the method of supply previously referred to. Thus, the introduction of high alternating pressures of 2,200 volts or more will not only improve the economy which the consumer may expect to derive, but will also enormously reduce the transmission loss, as compared with that occurring with the present customary pressure of 220 volts, in spite of the heavy initial outlay.

Finally, the author refers to the advantages enjoyed by the metallic lamps, of being less sensitive to variations of pressure, in comparison with the old carbon lamps. This may be of assistance in the design of distributing systems. A voltage drop in the consumer's mains, which would have been regarded as very unsatisfactory in the case of carbon lamps, is therefore of less consequence in this case, and a smaller cross-section of copper may be permissible.

The Economical Production of Good Petroleum Illumination.

By A. Guiselin.

(From the *Journal du Pétrole*, Jan. 20th, 1908.)

In a report presented to the recent congress of Bucarest, M. Pihan insisted upon the care necessary in the case of tests of combustion intended to determine the commercial value of oils used for illuminating purposes. The precautions suggested by this chemist seem to us so indispensable, that we are publishing the results of an interesting series of tests on the subject by MM. Guiselin and Madoulé at the Laboratoire Central de la Compagnie Industrielle de Petrole.

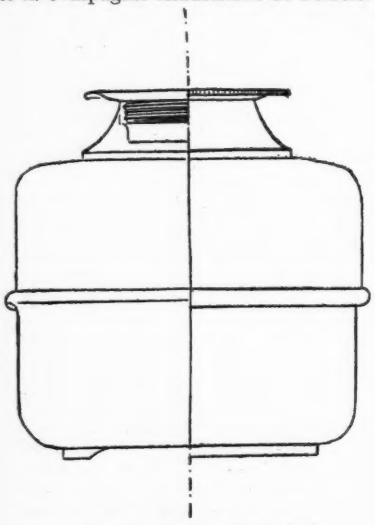


Fig. 1.—Scale of 56/100.

The object of these experiments was to study the influence upon the flame of the distance separating the upper level of liquid and the extreme upper end of the wick. The burners selected for the purpose of these tests were those of the round "Kosmos" type, with twelve slots, which are clearly the most generally used burners in France, while the varieties of petroleum utilized were selected among the varieties of oil of good quality sold under the names of "Pétrole de Luxe" and "Pétrole ordinaire" by the company referred to above.

In order to generalize the problem, MM. Guiselin and Madoulé have also utilized four distinct burners having carriers of different construction designed to distribute the air in different ways within the chimney; these are shown in Figs. 2, 3, 4, and 5. In all these four lamps the wicks utilized were of the same nature and the glass reservoirs of the same dimensions. The reservoirs shown in Fig. 1 were originally provided with 500 cc. of ordinary petroleum (Pétrole ordinaire). These were utilized in connexion with the burners previously described. At the commencement of the test, which lasted ten hours, the flame was adjusted to its maximum intensity, that is to say, a position such that the slightest raising of the wick would cause the flame to smoke. The candle-power of each flame was obtained at intervals of 1, 3, 6, 8, 9, and 10 hours. By utilizing these figures we obtain the curves shown dotted in Figs. 2a, 3a, 4a, and 5a. The difference in weight, measured very exactly in the case of each lamp, enables us to calculate:—

1. The mean consumption per hour.
2. The consumption per Carcel-hour.

The results here given show clearly enough the influence of the slightly different construction of the burners used.

This was repeated under exactly the same conditions, *i.e.*, utilizing the same reservoirs, the same wicks, and the same burners, but this time filling the reservoirs completely with 700 cc. of the same variety of petrol. In every case the candle-power and mean hourly consumption had increased. The curves obtained by plotting these results graphically are shown fully in Figs. 2b, 3b, 4b, and 5b.

This result, which is easily explained by the greater facility experienced by the petroleum in attaining the extremity of the wick, should cause no surprise, and only serves to confirm the recommendations of M. Pihan. But it is more surprising to find that in the case of all the burners the consumption per Carcel-hour is much greater in the first case than in the second, *i.e.*, when the lamps were completely filled. This result is

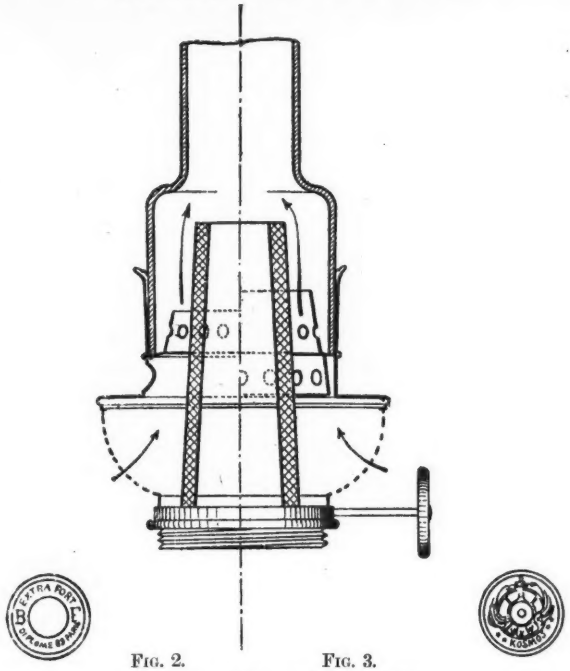


FIG. 2. FIG. 3.

"Kosmos" Burners (scale of 6/10).

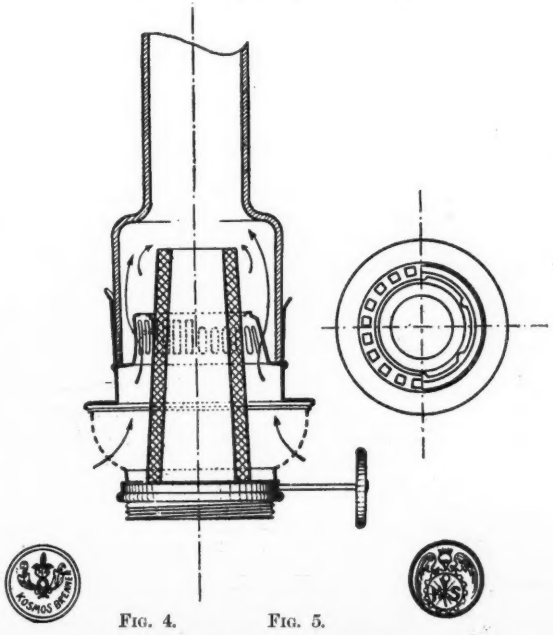


FIG. 4. FIG. 5.

Ordinary Burners (scale of 66/100).

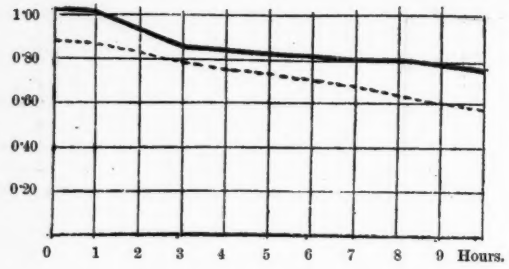


FIG. 2a (with burner shown in Fig. 2).

	With 500 cc.	With 700 cc.
Mean consumption per hour	31·8	33·5
Mean intensity ...	0·749	0·872
Consumption per Carcel-hour	42·45	38 39

Coefficient of economy, 0·903.

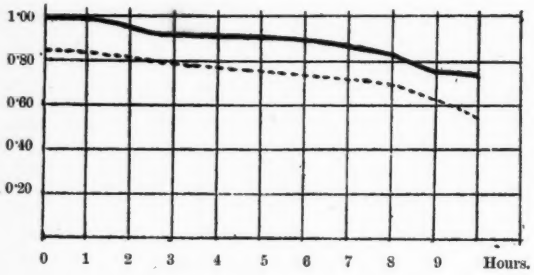


FIG. 3a (with burner shown in Fig. 3.)

	With 500 cc.	With 700cc.
Mean consumption per hour	30·7	32·0
Mean intensity ...	0·757	0·912
Consumption per Carcel-hour	40·55	35·09

Coefficient of economy, 0 862.

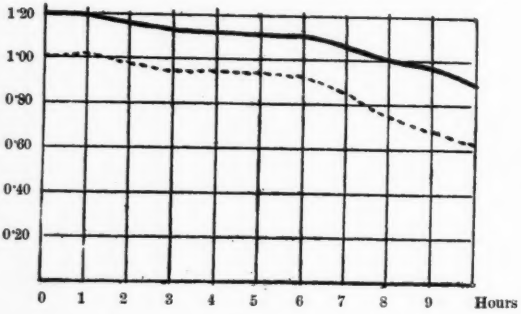


FIG. 4a (with burner shown in Fig. 4).

	With 500 cc.	With 700 cc.
Mean consumption per hour	35·0	38·6
Mean intensity ..	0 900	1·099
Consumption per Carcel-hour	38·82	35·12

Coefficient of economy, 0·905.

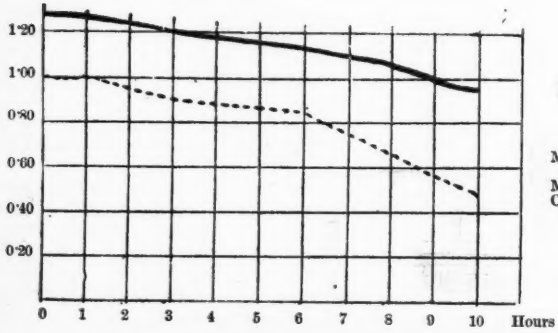


FIG. 5a (with burner shown in Fig. 5).

	With 500 cc.	With 700 cc.
Mean consumption per hour	31·2	37·5
Mean intensity ..	0·824	1·16
Consumption per Carcel-hour	37·86	32·3

Coefficient of economy, 0·931.

TESTS CARRIED OUT ON "PETROLE ORDINAIRE."

—— with 700cc. petroleum in reservoir.
..... with 500cc. „ „

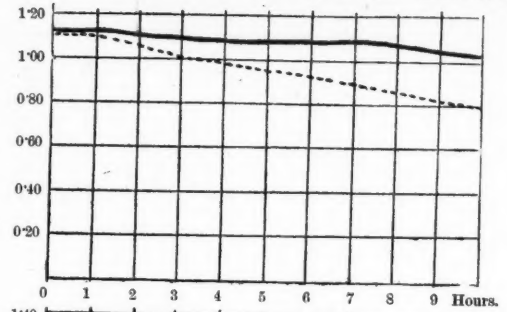


FIG. 2 b (using burner shown in Fig. 2).

	With 500cc.	With 700cc.
Mean consumption per hour	34·2	35·4
Mean intensity ...	0·973	1·101
Consumption per Carcel-hour	35·13	32·13

Coefficient of economy, 0·914.

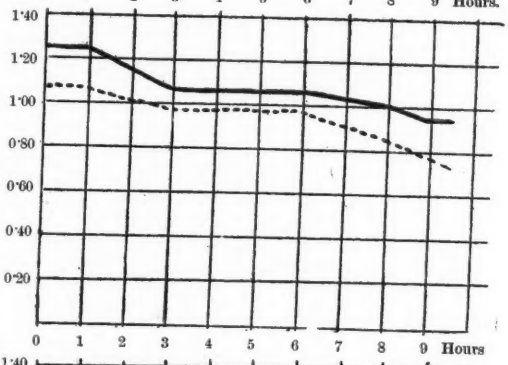


FIG. 3 b (using burner shown in Fig. 3).

	With 500cc.	With 700cc.
Mean consumption per hour	30·5	33·0
Mean intensity ...	0·799	0·918
Consumption per Carcel-hour	38·56	35·92

Coefficient of economy, 0·931.

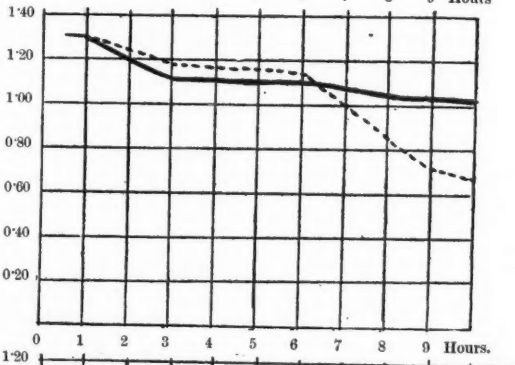


FIG. 4 b (using burner shown in Fig. 4).

	With 500cc.	With 700cc.
Mean consumption per hour	36·0	37·0
Mean intensity ...	1·067	1·102
Consumption per Carcel-hour	33·74	33·57

Coefficient of economy, 0·995.

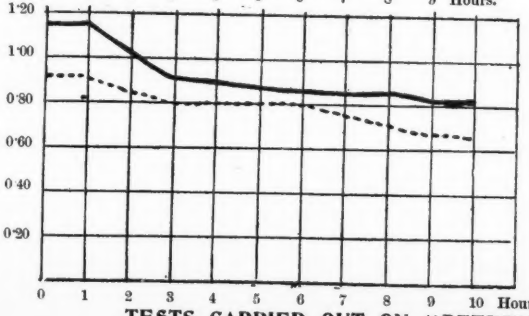


FIG. 5 b (using burner shown in Fig. 5).

	With 500cc.	With 700cc.
Mean consumption per hour	35·0	36·3
Mean intensity ...	0·936	1·102
Consumption per Carcel-hour	37·37	32·92

Coefficient of economy, 0·881.

TESTS CARRIED OUT ON "PETROLE DE LUXE."

—— with 700cc. petroleum in reservoir.
..... with 500cc. " "

of special interest, because it enables us to clearly demonstrate the economy which is effected by the consumer when he refills his lamp.

When the same series of burners was employed with a better quality of petrol the authors obtained results which enable us to draw the same conclusions.

of both kinds of petroleum, a greater candle-power is obtained when the reservoir is completely filled with 700cc. of oil than when it is only partially filled with 500cc.

In order to make the tests quite complete it would be necessary to repeat them, utilizing a constant level of petrol in the reservoirs. But the end which this

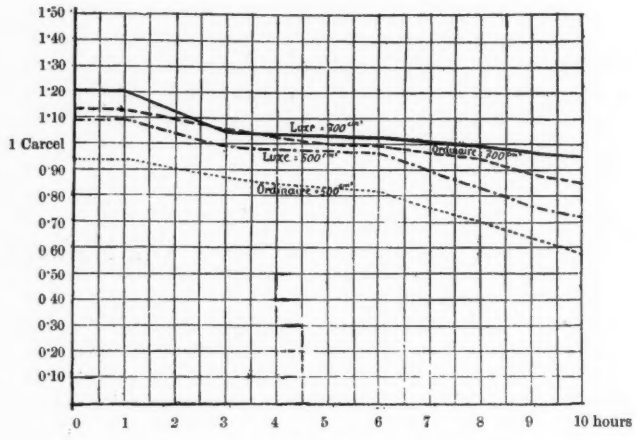


FIG. 6.

These curves show the mean results deduced from Figs. 2a, 3a, 4a, 5a, and 2b, 3b, 4b, 5b respectively.

The final average results deduced from the tests referred to are shown in Fig. 6. Here it appears, *firstly*, that the light obtained with "pétrole de luxe" is, on the whole, greater than that obtained by the use of "pétrole ordinaire," and, *secondly*, that in the case

interesting investigation has in view may be said to have been attained in so far as it enables us to advise the consumer to keep his lamp constantly refilled if he is anxious to obtain the most satisfactory illumination at the lowest expense.

The Influence of Fluctuations in Pressure on Glow Lamps.

By F. Hirschauer.

(Abstracted from the *Elektrische Zeitschrift*, Jan. 30th, 1908.)

The connexion between the alteration in candle-power of a glow lamp and the variation in pressure producing it is given by the following relation :—

$$h = Ce^n$$

where h=the candle-power of the lamp
e=the P.D. in volts
n,C,=constants which are the same for a particular type of lamp.

The author then proceeds to describe certain experiments which were carried out with the object of investigating this connexion, and determining the constants "n" and "C" for various types of lamps. The most important of these two constants from a practical point of view is "n," for this determines the variation in candle-power which is caused by a given change in P.D. In the table given below the author gives the value of this constant for various types of filaments in order of decreasing magnitude, and also the value of the alteration in candle-power which would be produced by a variation of $\pm 2{\cdot}5$ per cent. in the supply pressure.

Type of Filament.	Value of "n."	Variation in candle-power caused by an alteration of $\pm 2{\cdot}5$ per cent. in the pressure applied to lamp.
Nernst ...	10	50
Carbon ...	6·3	31·5
Tantalum ...	4·3	21·5
Osmium ...	4·2	21
Osram ...	4·0	20
Just-Wolfram	4·0	20

It will be seen that, as might have been expected, the sensitiveness to alteration in pressure is greatest in the case of the Nernst filament, and becomes less pronounced in the case of the metallic ones. We may also calculate out the permissible variation in pressure in order that the candle-power of the lamp may not vary more than 12 per cent. This works out as follows :—

Nernst	1·2	per cent.
Carbon	1·9	„ „
Tantalum	2·8	„ „
Osmium	2·85	„ „
Osram	3·0	„ „
Just-Wolfram ..	3·0	„ „

The use of the new metallic filament lamps may, therefore, be expected to lead to economy in the amount of copper used in two ways. In the first place, their greater efficiency means that, in order to produce a given candle-power at a given pressure, less current will be required, and hence a smaller cross section of copper is admissible. Secondly, we might allow a greater drop of P.D. in the case of metallic filament lamps, on account of the smaller change in candle-power, caused by a given variation in the pressure at the lamp terminals, referred to above.

Magnetite Arc Lamps.

By F. Dressler.

(Abstracted from the *Elektrotechnischer Anzeiger*, Jan. 30th.)

The magnetite lamp appears to occupy a position intermediate between the enclosed arc lamp and a lamp utilizing carbons of the ordinary variety, to which the air has free access.

In the intensity of the light it resembles the open arc, but in the length or time which may elapse before the lamp requires attention, it rather resembles the enclosed lamp. The arc itself, however, is not so steady as that in the case of the latter. In America this defect is tolerated on account of the long burning hours of the magnetite arc, and its consequent cheapness in maintenance.

The name of the lamp is derived from the main constituent of the negative electrode. The positive electrode usually consists of a slab of copper. It is not feasible to maintain an alternating current arc between metallic electrodes, and hence the magnetite arc lamp is essentially intended for direct currents.

In the case of the usual arc between carbon electrodes, about 85 per cent. of the light comes from the crater of the positive electrode; in the case of the magnetite arc, on the contrary, practically all the light comes from the vapour of the arc itself. Owing to this fact the distribution of light is essentially different from that of the ordinary carbon arc. The quality of the light is controlled by the nature of the negative electrode, which gradually wastes away while the positive remains practically unaffected.

The exact constituents of the negative electrode form the subject of many patents. In order to improve the steadiness of burning and also to improve the efficiency a certain percentage of Titanium compounds is desirable.

The time of wasting away of the negative is also very dependent on the material of which it is composed, and can be varied between 50 and 500 hours.

Table I.

Current, In Amperes.	Rate of Burning Away Millimetres per hour.
4	0·4–0·5
6	1·0
8	1·5–1·6

As a rule the constituents of the electrode are mixed into a fine paste with glycerine, and pressed into cylinders 200 mm. in length and 16 mm. in diameter.

One difficulty experienced in the design of these lamps is the production of fumes of red iron oxide, which deposit on the interior of the glass globe surrounding the lamp if precautions are not taken to secure good ventilation. Even so the production of such fumes is a drawback to the magnetite lamp, and renders it unsatisfactory for the illumination of interiors. For the actual process of combustion itself the amount of air necessary is smaller even that which is necessary in the case of enclosed arc lamps.

The author then refers to the regulating mechanism of the lamp. He appears to have found the arc of a very unsteady and fluctuating character.

Table II.

Type of Lamp.	Current Amperes.	Mean Hemispherical Intensity (H.K.)	Water/H.K. (Mean Hemispherical).
Ordinary Open Caslon Arc Lamp (Vertical Carbons)	4	2×240	0·65
	6	2×400	0·58
	8	2×620	0·52
Magnetite Arc ...	4	420	0·70
	6	710	0·61
	8	1,000	0·58
Enclosed Carbon Arc	4	350	0·86
	6	620	0·77
	8	750	0·72

Another drawback to which he makes reference is the necessity for some form of tray underneath the electrodes to catch the glowing particles occasionally falling from them which would otherwise crack the glass of the globe. The dimensions of this tray are such as to throw an unpleasantly deep shadow beneath the lamp.

The length of the arc varies from 20 to 26 mm,; with a current of 4 amperes

it is about 22 mm. The light yielded by the lamp is pure white in colour, receiving, however, a yellowish tinge from the admixture of glycerine. The naked arc acts powerfully upon the eyes and skin, and one would therefore suppose it to be of value for photographic purposes. Experiments have shown, however, that the magnetite arc does not equal the enclosed lamp for this purpose. The P.D. across the arc is usually about 72 volts. The series resistance is usually built into the frame of the lamp, which can be run straight off a supply pressure of 110 volts.

The results of some tests on open and enclosed carbon arc lamps and magnetite lamps are given by the author in Table II.

In this table the values of the intensity of open arc lamps are doubled on the ground that it is possible to run two such lamps in series on a P.D. of 110 volts.

On the whole the author considers that the drawbacks under which the magnetite arc at present suffers limit its application to cases in which the cost of electrical energy and labour are relatively high.

Luminous Signs for the Experiment Table in Darkened Lecture Theatres.

By H. J. Reiff.

(Abstracted from the *Physikalische Zeitschrift*, Nov. 1st, 1907.

There are many lecture experiments, such as the exhibition of vacuum tube discharges, &c., which have to be conducted in a darkened room, in order to be seen properly. In such cases an ordinary source of light, however well screened, is more or less unsatisfactory, for, even when directed away from the audience, and too subdued to interfere with the experiment, it is apt to dazzle the eyes of the lecturer.

For the purpose of revealing the situation of the various pieces of apparatus, the author has found the following device very convenient. He arranges small luminous signs, which are cut out of tin and coated with luminous paint, and are attached to or placed beside these pieces of apparatus, serving to indicate any feature which the lecturer desires to bear in mind. These signs can be arranged so as to be invisible to the audience by merely turning them with the coated face towards the lecturer; yet their brilliancy is so subdued that they do not produce any impression of dazzle. The signs frequently take the form of letters: they are also very useful for the purpose of indicating the polarity of mains, terminals, &c.

Although, as stated above, it is usually desirable to arrange these devices so as to be visible to the lecturer only, it is occasionally convenient to use them in another way. In experiments in which the gaze of the audience has to be rivetted for a long time in a certain direction, awaiting the appearance of some phenomenon, there is a danger that the effect may be missed owing to the direction of view being gradually altered. It is not easy to maintain one's direction of vision in the dark. The attention of the audience may therefore be focussed in the desired direction by the use of a luminous sign. Such a sign is easily visible at a considerable distance in a darkened room, yet there is no danger of the eyes of the observers being dazzled or confused by it.

REVIEWS OF BOOKS.

Elektrische Beleuchtung.

By Dr. Berthold Monasch.

(*Published by Dr. Max Janecke, Hanover.*)

Although this work appeared in 1906, it is possible that many of our readers have not yet had an opportunity of studying its contents, which are of great interest to those concerned with modern progress in the measurement and theory of illumination. We therefore give a brief summary of the ground covered in the volume referred to.

The book is systematically divided into eight sections, which are again subjected to subdivision. The first section, occupying about a quarter of the book, is devoted to photometry. The author defines the chief photometric quantities, and then passes on to the chief standards of light and photometers, which he describes in a brief but satisfactory manner. Special attention is paid to the photometry of arc lamps, and the description of the various methods is brought up to date by a reference to the integrating photometers of Matthews, Blondel, Ulbricht, &c.

The second and third sections deal with arc lamps and glow lamps respectively, and a useful summary of the recent progress in this subject is given. We note, however, that no reference is made to the magnetite arc, while the necessarily brief description of mercury lamps is already rendered out of date by the more recent introduction of the Küch lamp.

The fourth and fifth sections are devoted to the arrangement of lighting circuits and the maintenance of lamps generally, and contain much useful information. The seventh section is devoted to polar curves of light distribution from various illuminants, and represents a rather unique and certainly very serviceable collection of data. The seventh section is mainly concerned with questions of efficiency and cost of various illuminants, and also contains useful information, though the scientific reader would naturally not rely too closely on figures which necessarily depend upon somewhat local conditions. The eighth and last section contains a very brief discussion of illuminating problems in general.

On the whole, we think Dr. Monasch has produced a very useful book of reference. The illustrations are plentiful and clear, and the general scheme of the book is very convenient.

New Publications Received.

We have received a copy of the first number of *The Electrical Field*, which is described as a journal devoted to the interests of the contractor, and is got up in an attractive and readable form. The Editorial and Publishing offices are 30 and 31, St. Swithin's Lane, E.C.

CORRESPONDENCE.

International Photometrical Nomenclature.

[In matters of great scientific importance it is very essential that the original phrasing of communications should be preserved as closely as possible. We are, therefore, printing the letter which M. Laporte has kindly addressed to us, in French, but also append an English version by the side.]

MONSIEUR,—Je viens de lire dans le numéro de Février de *l'Illuminating Engineer* le compte rendu de l'article de M. Monasch sur la nécessité de bien définir les unités dont on se sert dans les questions d'éclairage et en particulier dans les mesures d'éclairement. Je partage entièrement cette opinion, mais, comme dans le travail que je viens de citer il s'est glissé une erreur, je tiens à la signaler à vos lecteurs.

Il est dit en effet qu'en Allemagne et en France on a adopté le mot de *lux* pour exprimer l'éclairement produit par un hefner placé à un mètre.

Depuis le Congrès de Genève qui, en 1896, sur la proposition de M. Blondel, a défini si heureusement les différentes grandeurs photomètriques et qui a choisi les unités correspondantes, le "lux" est employé en France dans les travaux de photomètrie de même que le "lumen" dont M. Monasch ne parle pas d'ailleurs. Mais en France, j'insiste sur ce point, nous lui donnons la même définition que le Congrès de Genève: le "lux" est l'éclairement produit par une bougie décimale placée à la distance de un mètre. Nous n'employons pas et n'avons jamais employé le mot "lux" avec la signification de l'éclairement produit par un hefner à un mètre.

Pour comparer les éclairements mesurés dans les différents pays, fussent-ils tous exprimés en lux, il est nécessaire de tenir compte de la valeur du rapport des unités d'intensité

DEAR SIR,—I have just been reading an abstract of an article by Dr. Monasch in the February number of *The Illuminating Engineer* on the necessity of defining, in a satisfactory manner, the units employed in problems of illumination, and particularly in the measurement of this quantity. I am in complete agreement with this opinion, but an error has crept into the article mentioned to which I wish to draw the attention of your readers.

It is, indeed, stated that in Germany and France the word "lux" has been adopted to signify the intensity of illumination produced by one Hefner, at a distance of one metre.

Ever since the Geneva Congress of 1896, which, acting on the suggestion of M. Blondel, defined the various photometrical quantities so successfully, and selected the corresponding units, the term "Lux" and also the term "Lumen," which, however, Dr. Monasch does not mention, have been employed in French treatises on photometry.

But in France—and I emphasize this point—we give this quantity the same significance as the Congress of Geneva: the "lux" is the intensity of illumination produced by a "bougie-décimale," placed at a mistance of one metre. We do not, and we never have used the word "lux" in the sense of the intensity of illumination produced by one Hefner at a distance of one metre.

In order to compare the intensities

lumineuse employées dans ces pays—
Comme :—
Hefner = 0·895 Bougie décimale
de même
Lux (dans les travaux allemands) = 0·895 lux (des travaux français).
La même observation s'applique naturellement à l'unité de flux lumineux le "lumen."

Heureusement la candle de spermaceti, la candle dixième de l'etalon Vernon Harcourt et la bougie décimale sont voisines les unes des autres et complètement équivalentes dans la pratique industrielle. L'Angleterre, l'Amérique et la France se trouvent donc employer en fait la même unité lumineuse et c'est une grande simplification fort avantageuse sous tous les rapports. Veuillez agréer....

F. LAPORTE.
Sous Directeur du Laboratoire Central d'Electricité.

of illumination, as measured in the different countries, if expressed in "lux," it is necessary to take account of the value of the relation between the standards of luminous intensity, employed in these countries.

Since the Hefner = 0·895 Bougie décimale, it follows that the Lux (as occurring in German treatises) = 0·895 Lux (as occurring in French treatises). Naturally the same observation applies to the unit of luminous flux, "the Lumen."

Fortunately, the spermaceti candle, the candle deduced as the tenth part of the intensity of the Vernon Harcourt standard and the "bougie décimale" approach each other closely, and may be regarded as completely equivalent from an industrial point of view. Practically the same unit of luminous intensity is in use in England, America, and France, and the resulting simplicity is, in every respect, a very great advantage. I am, yours faithfully,

F. LAPORTE,
Assistant Director at the Laboratoire Central d'Electricité.

The Moore Light.

DEAR SIR,—In reply to the letter from Mr. I. Wanterno in your February issue, I may say that I examined the spectrum of the Moore tube in the Savoy Hotel, and also of another tube filled with carbon dioxide, with my spectroscope. In both cases I found the spectrum consisting entirely of bright lines. In the case of the nitrogen tube at the Savoy Hotel the lines are chiefly collected in the yellow and red part of the spectrum, but in the case of the carbon dioxide tube they are well distributed through the blue and green as well; hence, although the spectrum is not continuous, the effect is to radiate a light not dissimilar to daylight.

With regard to Mr. Wanterno's second point, the inverse square law does not apply to the tube, as a whole, but I assume it applies to each element of the tube. The case is exactly parallel to that of the magnetic effect of an electric current. An element of a current in a conductor produces a magnetic force at any point inversely proportional to the square of the distance, but the magnetic force due to a long straight conductor carrying a current as a whole is inversely as the distance, and not as the square of the distance, as is easily proved by integration. I am, yours faithfully,

J. A. FLEMING.

Co-operation between Those representing Gas and Electric Lighting.

[Mr. Marks's letter, coming from a former president of the Illuminating Engineering Society, is particularly opportune as showing the possibility of co-operation and friendly discussion between those representing different systems of illumination.

We think it should be studied by those in this country who are still incredulous as to the results that have been achieved in this direction in the United States.]

MY DEAR MR. GASTER,—No. 1, vol. i. of your new journal has just come to hand. Permit me to congratulate you on the excellent showing you make in this introductory issue.

I understand that illuminating engineering as a speciality has not received much encouragement in England, and note that some of the British journals go so far as to say there is no need of an illuminating engineer as such. The publication of your journal will, if you maintain the high standard of the first number, go far towards giving the art of illumination a definite and fixed status. Sooner or later the opposition which has been shown by some of the other journals and by some engineers will, in my opinion, materially lessen if not disappear.

History repeats itself, and I assume you will have to go through in England what we have gone through in the United States. You will recall my experience in the organization of the Illuminating Engineering Society. Although there was much opposition at first to the formation of this Society, we now have almost 1,000 members scattered throughout the United States, and in some foreign countries, and are working in harmony with the older societies, such as the American Institute of Electrical Engineers, the National Electric Light Association, and the American Gas Institute. You will be gratified to learn that both the A.I.E.E. and the American Gas Institute have appointed committees to meet the Committee on Nomenclature and Standards of the Illuminating Engineering Society, with a view to agreeing on a unit of light. Thus the gas and electrical interests in the United States have for the first time been brought together in a practical way to endeavour to arrive at an understanding on questions of this character.

With renewed congratulations and best wishes for the success of your journal, I remain, Very truly yours,

L. B. MARKS.

The Mechanical Equivalent of Light.

SIR,—In your last issue appeared an interesting communication from Dr. H. Lux, giving a very complete list of tests upon different sources of light. This list contains, among other things, values for the luminous efficiency of the sources, and of the mechanical equivalent of light deduced from these figures; and the conclusion is drawn that the mechanical equivalent of light is not a definite quantity, but depends upon the form of the spectrum energy curve of the source.

As I have recently taken considerable interest in this subject, I should like in the first place to express agreement with the last statement, and to point out that it is a necessary consequence of the properties of the eye. As the eye is only sensitive to a very restricted range of vibrations, and varies in its sensitiveness for different parts of that range, it is obvious that if we define the mechanical equivalent of light as the number of watts or calories per second, per candle-power of white light, we are beset with difficulties as to the exact limits between which the radiation should be included in our measurements; or as to differences between the absorptive properties of any screens we may employ, and that which would make our radiation measuring device equivalent to the eye. Even if a perfect screen were obtained, it is obvious that a source having selective emission of wave-lengths corresponding to the maximum sensitiveness of the eye must give a lower value for the mechanical equivalent of light.

On this account it appears to me futile at the present time, with our imperfect knowledge both of the sensitiveness of the eye and of the absorbing properties of screens over a long range, to obtain anything like a definite value for the mechanical equivalent of white light. But the difficulty disappears when we employ monochromatic light of a definite wave-length, and especially if we select that wave-length as about ·54μ, which appears to be fairly definitely known as the point of maximum sensitiveness of the eye. In the neighbourhood of this point small variations are of less importance, and if we employ a discrimination method of comparing the intensity of the monochromatic source with that of a standard lamp, and arrange that the intensity of illumination at our photometer is some definite value (say 1 candle-foot), to avoid possible troubles with the Purkinje phenomenon, I see no reason why any serious indefiniteness should arise.

For the above reasons, in the recent investigations made by Mr. Jolley and myself, referred to in your last issue, an attempt was made, probably for the first time, to determine what we consider to be *the* mechanical equivalent of light, directly, by obtaining a beam of monochromatic yellow-green light by a prism, measuring its luminous intensity by a discrimination photometer, and the radiation by a bolometer. Measurements with white light were also made, but were regarded as of subsidiary importance.

While agreeing with Dr. Lux, therefore, as to the variations in the value of the mechanical equivalent obtained by tests on lamps, I am extremely surprised at the low values he obtains in several cases. Until three years ago all the results obtained by careful investigators on the Continent and at Cornell gave values for the mechanical equivalent of the Hefner from ·108 watts (Angstrom) to ·5 watts or higher. Within this time, however, Wedding

has given values as low as ·0016, Russner ·02, and Dr. Lux ·014 watts per Hefner. Curiously, as far as I can make out, Wedding has used a water cell only for absorbing the heat rays, and consequently should have obtained results which were too high, as was the case with the earlier workers. Russner and Dr. Lux have, however, worked with the green solution of double sulphate of iron and ammonium discovered by Nichols, and in some experiments which Mr. Jolley and I made lately with this solution we discarded it, owing to its becoming turbid, indicating chemical changes in its constitution. Whether this has affected the results of Russner and of Dr. Lux I do not know, but it is clear that the mechanical equivalent cannot be less than the value for the monochromatic light of ·54μ, for which we find the value ·0598 watts per c.-p., or ·0538 per Hefner. As this is the first time that this determination has been made, it would be unfair to lay too much stress upon it, although considerable care was taken. But I would most certainly urge that attempts should be made by as many workers as possible to get a definite value of the mechanical equivalent for one wave-length by direct measurement, instead of spending time on absorption tests which seem to give such hopelessly discordant results.

In the series of articles I am writing, I hope shortly to give a complete account of the early and recent work on this important subject.

I am, Sir,

Yours faithfully,

CHARLES V. DRYSDALE.

Northampton Institute, London,
February 19th, 1908.

Review of the Technical Press.

Illumination.

Some discussion has been raised in several of the American journals by a recent paper before the Illuminating Engineering Society by Dr. Seabrook, in which the physiological effect of illuminants was discussed. Dr. Seabrook mentioned the bad effects of excessive intrinsic brilliancy on the eye, and suggested that under normal conditions the eye rested itself by continual movement, so that a different portion of the retina was constantly being presented to the light.

He also dealt with the effects of light of different colours, and expressed the view that rays of short wave-length were the most effective in causing physiological action, the effect becoming more marked as we proceed towards the ultraviolet. In commenting on this point it is pertinently remarked in *The Electrical World* that the fact that the eye is most sensitive to yellow light must surely show that physiological action is most readily caused by rays of this colour.

Another recent paper of interest is that of Legg and Townsend (reported *Elec. World*, Feb. 1st). The illumination in some Chicago reading-rooms is discussed. Some interesting figures are given of the order of illumination provided, which appears to have usually been sufficient, and the order of cleanliness, which was not. In one case the effect of dusting the lamps above the reading tables was to increase the light by 75 per cent., while an average of about 25 per cent. seems to have been obtained. It is possible that very similar results would be obtained in many libraries in this country were the lamps examined. The order of illumination necessary in order to produce a general effect, apart from that intended for reading, is given as 0·3 to 0·5 per cent. The reading illumination appears to have varied from 1 to 3 candle-feet, and the authors remark that readers usually preferred to have as low a value as they could read by with comfort.

The valuable paper by Mr. Basset Jones on the relation of architectural principles to illuminating engineering was mentioned in the last review. It is now available in the January number of the Society's *Transactions*, together with the discussion.

Dr. Monasch (*Jour. für Gas*, &c., Jan. 25th, Feb. 1st and 8th) discusses the distribution of light from various forms of portable lamps, among which he includes electric reading lamps, petroleum kitchen lamps, &c. He gives the distribution curves of the various lamps under consideration. In the case of a reading lamp some form of shade is essential, because the form is usually such as to throw a shadow just where the light is required. The common "kitchen" lamp comes in for some deserved criticism. These lamps are usually suspended on the wall with the object of illuminating the whole room. To assist this object a reflector throwing the light out at right angles to the room is provided. The illumination so produced is, however, rarely satisfactory, and the result is that the lamp is often taken off the wall and placed near at hand on the table; for this purpose the reflector is specially ill-adapted, for it throws the light straight into the eyes of the observer instead of downwards on to the table. Dr. Monasch also discusses the various methods of rating lamps. From one point of view the mean spherical candle-power is an impartial basis of comparison between different lamps, but frequently fails to express the illuminating value of a source under practical conditions. Dr. Monasch winds up by giving a series of curves of horizontal illumination, plotted out from results obtained by experiment, and intimates that this is really the most satisfactory method of comparing results.

The editorial columns of the *Journal of Gaslighting* contain some reference to the supposed difficulty in co-operation experienced between those representing the gas and electrical lighting in the

Illuminating Engineering Society. That there is in reality very serviceable and satisfactory co-operation between the representatives of both forms of lighting in the United States is suggested to those who have been studying the question by the recent combined action of the Illuminating Engineering Society, the Institute of Electrical Engineers, and the Institute of Gas Engineers, in order to discuss the question of standards of light.

The Electrical Review for Feb. 7th contains some sensible remarks on the subject of the inspection of residence lighting, in order to secure the goodwill of the consumer.

The correspondence on the measurement of street illumination still continues. Mr. Mackenzie emphazises the fact that all such measurements are only an indication; we are also concerned with the physiological impression of brightness or otherwise that the pedestrian in the street receives. Such an impression is very greatly influenced by the vertical illumination which does not receive justice by the horizontal method. Mr. Wild is impressed by the inaccuracies of street photometry, arising very largely from the low order of illumination which has to be measured. He also refers to the possibility of the cosine law not being applicable at the very oblique angles at which the rays in these cases fall upon the photometer screen, and the limit to accuracy set by the possibility of "angle-errors."

Photometry.

No very notable contributions to the literature on this subject have been made since the last review, though several of the articles mentioned therein have been reproduced elsewhere.

The Electrician (Feb. 2nd) contains a résumé of the recent study of plain and frosted lamps by Hyde and Cady (*Bull.* of the Bureau of Standards). One interesting point raised in this paper is the question of the great reduction candle-power question of glow lamps with frosted bulbs during their life. This seems to be entirely due to the light-absorbing deposit formed on the bulb of the lamp, and not any alteration in the structure of the filament.

The new form of 'Universal Photometer' of P. S. Millar is discussed in several places, while the recent article in the *Electrotechnische Zeitschrift* dealing with the photometrical laboratory of Messrs. Körting and Matthiesen has been also reproduced.

Houston (*Phys. Zeit.*, Feb. 4th) discusses a new form of spectrophotometer.

Electric Lighting.

The recent literature on this subject is again mainly concerned with the metallic filament lamps and the effect of their introduction on industrial conditions.

Hirschauer (*E.T.Z.*, Jan. 30th) calculates the influence of variations in the supply P.D. on the light given by the various existing types of glow lamps. The candle-power of an incandescent lamp is connected with the P.D. across it by the following relation:—

$(c.p.) = C(P.D.)^n$, where C. and n. are constants.

The most important constant is n, as this determines the variation in candle-power caused by an alteration in P.D. The author gives a table of results showing the variation in light caused by a variation of $\pm$ 2·5 per cent. in the P.D. across the lamp.

Electrical Engineering (Feb. 13th) contains a résumé of this article and a previous one on the same subject by Loring (*Elec. World*, Jan. 4th).

The situation has also been dealt with in an interesting article by Hobart (*Times Eng. Supplement*, Feb. 5th). The author remarks on the drawbacks of applying metallic lamps to high pressure circuits, and even advocates the adoption of a 2,200 volt supply stepped down to 25 volts at the consumer's premises. He also points out the short-sighted policy of the engineer, who, fearing a loss of revenue, does not encourage consumers to adopt the most efficient lamps.

This last point is taken up in a long article by a writer in *The Electrical Times*. He, too, believes that the new lamps will ultimately prove a benefit to supply authorities, in spite of a temporary loss in revenue. It will be remembered that "A Lamp Maker" (*Elec. Engineer*, Dec. 6th) took a somewhat gloomy view of the situation.

O'Hanlon (*Elec. Rev.*, Jan. 3rd) discusses the design of small transformers for use with metallic filament lamps.

In *The Electrical Engineer* for Feb. 21st appears an abstract of a recent paper by Remané before the Electrotechnische Verein. The author gives a summary of the three chief methods of making Tungsten filaments, the "Paste" method of Auer, the Just flashing process, and the Kuzel colloidal method. He also describes more particularly the manufacture of Osram lamps, which are made

by the "paste process," and gives the results of tests on these lamps, according to which a life of 1,000 hours is possible without the watts per H.K. having very appreciably altered from the original value of near unity.

Dressler (*Elek. Anz.*, Jan. 30th) gives a description of the magnetite arc. This lamp has found its widest application in the United States, and is not so well known in Germany. He describes the essential construction of the positive copper-slab electrode, and the negative magnetite and titanium one, the rate of burning away in which can be controlled between wide limits. Thus one negative electrode 200 mm. long and 16 mm. diam. lasts 50–500 hours according to its composition.

In the case of the carbon arc 85 per cent. of the light comes from the positive electrode, and 10 per cent. from the negative. In the magnetite arc practically all the light comes from the arc itself, which is 20–26 mm. in length, and usually requires about 70 volts.

The light given by this lamp is very white in character, but the author considers it somewhat unsteady. The naked arc is liable to cause inflammation of the eyes, if incautiously used, owing to the presence of a strong ultra-violet element.

The watts per H.K. he gives as about 0·5 to 0·6 (per mean hemispherical intensity).

The Elec. World (Jan. 18th and Feb. 1st) contains abstracts of the recent patents for the Cazin metallic filament, and the Heraeus mercury vapour lamps.

Gas, Oil, and Acetylene Lighting.

Under the heading of 'An Illuminating Power Test twice removed from Modern Conditions' *The Journal of Gaslighting* discusses a recent judgment against an English gas company, in which the use of an obsolete form of burner for gas testing, specified by an Act of 1868, was enforced.

Webber (*Gas World*, Feb. 6th) insists on the fact that photometrical measurements ought only to serve as a tool, and that the conclusions to be drawn from them must be modified by the special circumstances of the case.

In particular, when several different methods of securing a given ground illumination are possible, we must apply ourselves to the problem of also producing the most tasteful effect. The author illustrates this point by means of three examples of different arrangements of lights, arranged to give the same illumination, but differing in their æsthetic results. He also considers that electric lighting has hitherto suffered from the æsthetic point of view through lack of units of exactly the right intensity, and remarks that the infinite gradations in the value of incandescent gas units is a great advantage in this respect.

A writer in a recent number of the *Zeitschrift für Beleuchtungswesen* comments on the necessity for some effort at standardization in the matter of inverted incandescent mantles and burners. At present a great variety of such fittings are in use, owing to the narrow view taken by many manufacturers who have constructed their burners in such a way that they can only be used with the one particular type of mantle sold by the same firm. The object of this is to force a consumer who has adopted a certain type of burner to always buy his mantles from the same source. A similar plan, at one time adopted by glow lamp makers, was to make the lamps in such a way as only to fit one special holder.

Naturally all such efforts have the effect of disgusting the consumer with that particular form of lighting. The rapid strides of the upright type of mantles were only attained through adherence to uniformity. A recent letter addressed to the various makers of incandescent mantles on the subject elicited favourable support, and it is hoped that some agreement on this vital point will soon be reached.

Guiselin (*Journal du Pétrole*, Jan. 20th) gives the results of some recent tests of oil lamps carried out in accordance with the recommendations of the recent Petroleum Congress. One essential point brought out by these tests is the influence on the efficiency of the lamp of the amount of oil in the reservoir. A lamp containing 700 cc. of oil invariably gave better results than one containing 500 cc.

The consumer is therefore recommended to fill his lamp at frequent intervals in order to get the best results.

Acetylene for February contains some interesting information as to the application of acetylene to "flare lights," buoys, and lighthouses. There is also an account of the system of free inspection of acetylene generators by the French Society of Acetylene Apparatus Owners. Prizes are offered for the best kept arrangment. The writer regrets that there seems but little prospect of such co-operation becoming general in this country.

Miscellaneous.

Some discussion has recently taken place with reference to the influence of

light on selenium in *Nature* (Dec. 26th, Jan. 2nd and 9th). It has been contended by Hammer and others that the enclosure in a vacuum selenium cell intended for light measurement is beneficial in that it eliminates "photoelectric" effects, *i.e.*, the production of an E.M.F. under the influence of light.

Minchin, however (see *Nature, ref. cit.*), found that the result of placing a selenium cell in an exhausted envelope was to greatly decrease the resistance and destroy the sensitiveness of the cell to light. It was suggested subsequently that this effect might be due to the fact that a mercury pump had been used, for mercury vapour readily combines with selenium.

On repeating his experiments Minchin found this to be the case. When exhaustion was carried out by another method in which no mercury was used, the sensitiveness was not destroyed and the resistance was somewhat increased.

The Electrician (Feb. 21st) abstracts a recent paper by Meritt on the recovery of selenium cells after exposure to light. Some curves are given illustrating this recovery, which the author finds to closely resemble the peculiarities of certain phosphorescent substances which he has recently been studying.

ILLUMINATION.

Editorials. How is Intrinsic Brilliancy Harmful? (*Elec. Rev.* N.Y., Jan. 18; *Elec. World*, Jan. 18).
Editorial. Inspection of Residence Lighting (*Elec. Rev.*, Feb. 7).
Legg, E. F., and Townsend, H. A Study of the Illumination of Interiors (*Elec. World*, Feb. 1).
Monasch, B. Lichtausstrahlung und Beleuchtung bei Transportablen Tischlampen (*Journal für Gas*, &c., Jan. 25, Feb. 1, 8).
Trotter, Harrison, Mackenzie, Smith, Wild, &c. The Measurement of Illumination and City Lighting (*Elec. Rev.*, Jan. 24, 31, Feb. 14, 21).
The Third Annual Show at Chicago (*Elec. Rev.* N.Y., Jan. 25).
Drawing Office Illumination (*Electrician*, Feb. 4).
In the Camp of the Illuminating Engineer (*Jour. of Gaslighting*, Feb. 11).

The Transactions of the Illuminating Engineering Society for January also contain :—
Basset Jones, W. The Relation of Architectural Principles to Illuminating Engineers.
Puffer, W. L. The Variables of Illuminating Engineering.
Lansingh and Heck. Fixture Design from the Standpoint of Illuminating Engineers (Discussion).

PHOTOMETRY.

Houstoun, R.A. Ein neues Spektrophotometer von Hüfner Typus (*Phys. Zeit.*, Feb.).
Hyde and Cady. A Comparative Study of Plain and Frosted Lamps (*Electrician*, Feb. 2, from the *Bull.* of the Bureau of Standards).
Miller, P. S. A New Universal Photometer (*Elec. Rev.* N.Y., Jan. 25, 1908; *Elec. World*, Jan. 18).
Modern Photometrical Apparatus (*Electrician*, Feb. 20, from *E. T. Z.*, Jan. 2).

ELECTRIC LIGHTING.

Auerbacher, L. J. High Efficiency Lamps in Kaiserlautern (*Elec. World*, Feb. 1).
Dressler, F. Magnetitbogenlampen (*Elek. Anz.*, Jan. 3).
Hirschauer, F. Einfluss von Spannungsschwankungen auf Glühlampen (*E.T.Z.*, Jan. 30).
Hobart, A. M. Some aspects of the Metallic Filament Lamp Situation (*Times*, Eng, Supplement, Feb. 5).
O'Hanlon, J. B. The Design of Small Transformers for Metallic Filament Lamps (*Elec. Rev.*, Jan. 31).
Remané, H. The New Metal-Filament Lamps, their Qualities and their Commercial Importance (*Elec. Engineer*).
The Tantalum Lamp in Central Station practice (*Elec. World*, Jan. 18).
The Heraeus Lamp Patents (*Elec. World*, Jan. 18).
The Cazin Metallic Lamp Patents (*Elec. World*, Feb. 1).
Helion Lamp Patents (*Elec. World*, Jan. 18).
Metallic Filament Lamps and Revision of Tariffs (*Elec. Times*, Jan. 23 *et seq*).
Carbon and Metallic Filament Lamps (*Elec. Engineering*, Feb. 13).
Searchlights (*Elec. Engineer*, Jan. 31, 1908).
Webber, W. H. Y. The newer types of Electric Lamps.

GAS, OIL, AND ACETYLENE LIGHTING.

Editorial. An Illuminating Power Test Twice Removed from Modern Conditions (*Jour. of Gaslighting*, Jan. 28).
Guiselin. Pour obtenir economiquement un bon Eclairage du Pétrole (*Jour. du Pétrole*, Jan. 20, 1908).
Himmel. Neue Zentralzündung für offentliche Beleuchtung (*Jour. für Gas*, Feb. 1).
Little, T. J. Gaslighting in the Factory (*Am. Gaslight Jour.*, Jan. 27).
Seabrook, H. (Correspondence). Combination of Gas and Electricity (*Elec. Rev.*, Feb. 7).
Walker, S. F., &c. (Correspondence). Gas *v.* Electricity (*Elec. Rev.*, Feb. 7).
Lighting Gas Lamps at a distance by Electricity (*Gas World*, Jan. 11 and 18).
Webber, W. H. Y. Illustrations of the Art of Gaslighting (*Gas World*, Feb. 8).
Whitwell, C. Gas in Libraries (*Electrical Engineer*, Jan. 31).
Einheitliche Glühkorper fur hängendes Gasglühlicht (*Zeit. für Bel.*, Jan. 10).
The Lighting and Ventilation of Schools (*Gas World*, Feb. 15).

MISCELLANEOUS.

Merrit. The Recovery of Selenium Cells after exposure to Light (*Electrician*, Feb. 21, from the *Physical Review*).
Influence of Light on Selenium (*Elec. Rev.*, N.Y., Jan. 25, Feb. 1, *Nature*, Dec. 26, Jan. 2, Jan. 9).

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

27,412A/07. Arc lamps. Jan. 13 (D.A. Dec. 12, 1907). H. Bevis and A. E. Angold Peel Works, Adelphi, Salford.
1,596. Arc lamps. Jan. 23. H. E. Moul, 18, Kensington Court Place, London.
2,103. Lamps. Jan. 30. Cutler, Wardle & Co., Ltd., and W. Wardle, 55, Market Street, Manchester.
2,120. Arc lamps. Jan. 30. A. H. Greening and C. Petitjean, 15, Clifford's Inn, London.
2,254. Supports for lamp filaments. Feb. 1. A. H. S. Colebrooke, Stanley Road, Huyton, near Liverpool.
2,261. Arc lamps. Feb. 1. A. Holman, 44, West George Street, Glasgow.
2,707. Incandescent lamps. Feb. 6. J. Howard, 70, Chancery Lane, London.
2,797. Incandescent lamp. Feb. 7. W. E. Lake, 7, Southampton Buildings, London (from R. Jahoda and Elektrische Glühlampenfabrik "Watt" Scharf, Loti and Latzko, Austria).
13,076. Incandescent lamps. Feb. 11. J. A. Leon, 60, Queen Victoria Street, London.

II.—GAS LIGHTING.

756. Incandescent lamps. Jan. 13. E. Kreuzberger, 72, Acomb Street, Manchester.
793. Inverted incandescent burners (C.S.). Jan. 13. M. Graetz, 18, Southampton Buildings, London.
887. Holders for inverted mantles. Jan. 14. M. Peiser, Chancery Lane Station Chambers, London.
1,026. Supporting incandescent mantles. Jan. 16. M. Kriegel, Prudential Buildings, Corporation Street, Birmingham.
1,074. Burners for incandescent lamps (C.S.). Jan. 16. A. Pöschl, Thanet House, Temple Bar, London.
1,453. Controlling, igniting, and extinguishing gas from a distance. Jan. 21. H. L. Down and Telephos, Ltd., 115, Cannon Street, London.
1,486. Regulating Bunsen burners for incandescent light. Jan. 22. P. Wigley, G. N. Arculus, and J. Warry, 128, Colmore Row, Birmingham.
1,493. Distance gas-lighters. Jan. 22. H. E. Kelvey, Cromford House, The Square, St. Anne's-on-the-Sea.
1,757. Automatic lighting and extinguishing. Jan. 25. J. L. Cloudsley, jun., 18, Southampton Buildings, London.
1,789. Intermittent gas-lighting. Jan. 27. H. J. Pearce, Zetland Lodge, New Cross Road, London.
1,844. Inverted regenerative incandescent lamps (C.S.). Jan. 27. L. Zechnall and J. Altman, 70, Chancery Lane, London.
1,852. Manufacture of incandescent mantles (C.S.). Jan. 27. W. E. Lake, 7, Southampton Buildings, London. (From Akt.-Ges. für Selas-Beleuchtung, Germany.)
1,881. Inverted incandescent burners (C.S.). Jan. 28. G. Cranmer and H. Cheshire, trading as Cranmer & Cheshire, Carlton Buildings, Paradise Street, Birmingham.
1,994. Gas lamps. Jan. 29. J. Keith and G. Keith, 65, Chancery Lane, London.
2,057. Manufacture of double incandescent mantles (C.S.). Jan. 29 (I.C., July 27, 1907, Germany). Akt.-Ges. für Selas-Beleuchtung, 7, Southampton Buildings, London.
2,240. New method of producing incandescent mantles. Jan. 31. The British Cerofirm Co, Ltd., Chancery Lane, London. (From the Cerofirm-Ges., m b.H., Germany.)
2,285. Inverted incandescent burners (C.S.). Feb. 1. J. W. Bray, Sunbridge Chambers, Bradford, Yorks.
2,300. Systems of gas-lighting (C.S.). Feb. 1. R. E. Andrews, 37, Oakhurst Grove, East Dulwich, London.
2,330. Manufacture of mantles for inverted burners. Feb. 1. W. Kampf, 4, South Street, Finsbury, London.
2,352. Igniting gas jets in buildings, &c. Feb. 3. F. Bloomer, 5, Corporation Street, Birmingham.
2,572. Preparation of mantles or incandescent bodies (C.S.). Feb. 5. M. Weickert, 37, Essex Street, Strand, London.
2,605. High-pressure incandescent burners. Feb. 5. T. Glover, 173, Fleet Street, London.
2,606. Street lamps, &c., for incandescent lighting. Feb. 5. T. Glover, 173, Fleet Street, London.
2,607. Incandescent street lamps, lanterns, &c. Feb. 5. T. Glover, 173, Fleet Street, London.

2,608. High-pressure incandescent burners. Feb. 5. W. Glover, 173, Fleet Street, London.
2,701. Incandescent burners. Feb. 6. E. M. Smith, 33, Cannon Street, London.
2,800. Incandescent burners. Feb. 7. A. S. Francis, 77, Chancery Lane, London.
2,816. Lighting and extinguishing from a distance. Feb. 7. E. H. Elton and R. Stephens, 27, Chancery Lane, London.
2,973. Inverted incandescent pressure gas lamps (C.S.). Feb. 10. (I.C. Feb. 26, 1907, Germany.) M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.
3,055. Incandescent mantles (C.S.). Feb. 11. (I.C. Nov. 16, 1907, U.S.A.) A. P. White, 28, New Bridge Street, London.

III.—MISCELLANEOUS.

(Including lighting by unspecified means, and inventions of general applicability.)

943. Portable advertising lamps. Jan. 15. D. H. Warden, Imperial Chambers B., Colmore Row, Birmingham.
1,064. Lighting apparatus (C.S.). Jan. 16. W. Lindner, 116, High Holborn, London.
1,113. Burners for acetylene flare lamps. Jan. 17. W. Harris and F. R. Stone, Lloyds' Bank Buildings, Bristol.
1,400. Oil or vapour lamps. Jan. 21. H. Brough and J. Major, 18, Southampton Buildings, London.
1,866. Acetylene gas light. Jan. 28. M. Charissi, 64, Bushey Hill Road, Peckham, London.
2,104. Vapour lamps. Jan. 30. W. Hartley, 5, Corporation Street, Birmingham. (Addition to No. 4,014/06.)
2,492. Turning on and off gas or electric lamps from a distance (C.S.). Feb. 4. G. V. Wengelin, 111, Hatton Garden, London.
3,087. Incandescent petroleum lamps. Feb. 11. M. Malkiel, 6, Lord Street, Liverpool.
3,163. Acetylene lamps (C.S.). Feb. 12. L. Jouvenet, Birkbeck Bank Chambers, London.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

24,232. Incandescing bodies for lamps. Oct. 30, 1906. Accepted Feb. 5, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London (from Allgemeine Elektricitäts-Ges., Germany).
24,233. Incandescent lamps. Oct. 30, 1906. Accepted Feb. 5, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From Allgemeine Elektricitäts-Ges., Germany.)
2,963. Arc lamps. Feb. 6, 1907. Accepted Feb. 12, 1908. J. M. Wellington and W. F. Daniell, 88, Chancery Lane, London.
2,964. Arc lamps. Feb. 6, 1907. Accepted Feb. 12, 1908. J. M. Wellington and W. F. Daniell, 88, Chancery Lane, London.
3,060. Arc lamps. Feb. 7, 1907. Accepted Feb. 12, 1908. A. D. Jones, 39, Hartham Road, Holloway.
4,364. Incandescing bodies for lamps. Feb. 21, 1907. Accepted Feb. 5, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From The General Electric Co., U.S.A.)
5,424. Incandescent lamps and their supports. March 6, 1907. Accepted Jan. 22, 1908. R. J.-B. M. Damseaux, 111, Hatton Garden, London.
5,575. Conductors for use as incandescing bodies. March 7, 1907. Accepted Jan. 29, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
7,279. Arc lamps. March 26, 1907. Accepted Jan. 22, 1908. H. E. Angold and The Maxim Electrical Co., Ltd., 18, Southampton Buildings, London.
8,642. Mounting incandescent lamp filaments. April 13, 1907. Accepted Feb. 12, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
9,345. Pendant lamps. April 22, 1907. Accepted Feb. 12, 1908. T. Elliott, 110, Strand, London.
11,717. Incandescence filaments of tungsten or its alloys (C.S.). I.C. May 19, 1906, Germany. Accepted Jan. 22, 1908. Siemens and Halske Akt.-Ges., Birkbeck Bank Chambers, London.
22,746. Manufacture of incandescence filaments (C.S.). I.C. Oct. 26, 1906, Germany. Accepted Feb. 12, 1908. Siemens & Halske Akt.-Ges., Birkbeck Bank Chambers, London.
24,706. Arc lamps (C.S.). Nov. 7, 1907. Accepted Feb. 12, 1908. Johnson & Phillips, Ltd., and C. F. Tubbs, Birkbeck Bank Chambers, London.
25,846. Arc lamps (C.S.). I.C. Dec. 5, 1906, Germany. Accepted Jan. 22, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
27,541. Incandescent lamps (C.S.). Dec. 13, 1907. Accepted Feb. 5, 1908. C. Pauli, 20, High Holborn, London.

II.—GAS LIGHTING.

1,862. Lighting apparatus for gas lamps (C.S.). Jan. 24, 1907. Accepted Jan. 29, 1908. F. W. Howorth, 46, Lincoln's Inn Fields, London. (From Deutsche Gasglühlicht Akt.-Ges. (Auerges.), Germany.)
2,736. Burners for lighting and heating. Feb. 4, 1907. Accepted Jan. 22, 1908. E. J. Parker, 14, Alwyne Villas, Canonbury, London.

2,749. Burners for incandescent lamps, &c. Feb. 4, 1907. Accepted Feb. 12, 1908. J. H. D. Gooding, 343, Queen's Road, London.
3,101. Inverted incandescent lamps (C.S.). I.C. Feb. 10, 1906, Germany. Accepted Feb. 5, 1908. Akt.-Ges. für Selas-Beleuchtung, 7, Southampton Buildings, London.
5,139. Incandescent burners. March 4, 1907. Accepted Jan. 22, 1908. E. Hinton and F. A. Andrews, 82, New Bond Street, London.
10,294. Lighting arrangements for incandescent burners. May 3, 1907. Accepted Feb. 5, 1908. J. Keith, 65, Chancery Lane, London.
11,734. Lighting and extinguishing gas lamps (C.S.). May 21, 1907. Accepted Jan. 29, 1908. H. H. Johnson and E. Moin, 77, Colmore Row, Birmingham.
15,893. Lighting gas at a distance. I.C. July 10, 1906, Switzerland. Accepted Feb. 5, 1908. F. Blaser, 6, Lord Street, Liverpool.
19,283. Inverted incandescent lamps (C.S.). Aug. 27, 1907. Accepted Jan. 22, 1908. G. Steinicke, 6, Lord Street, Liverpool.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

2,470. Incandescent petroleum burner. Jan. 31, 1907. Accepted Feb. 5, 1908. E. Holy, 18, Southampton Buildings, London.
7,726. Incandescent vapour lamps (C.S.). April 2, 1907. Accepted Jan. 29, 1908. C. A. Black and G. M. Thompson, 18, Southampton Buildings, London.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.—Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

4

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EDITORIAL.

THE subjects which form the basis of our editorial in this number all serve to illustrate one point, to which we are constrained to attach special importance—the value of co-operation. One of the most pleasing features in the recently issued report of the National Physical Laboratory was the evidence of mutual help rendered to each other by the Engineering Standards Committee, the International Electrotechnical Commission, and the Laboratory. Equally satisfactory is the evidence of co-operation between the National Physical Laboratory and the laboratories of France, Germany, and the United States, with a view to the settlement of vexed questions in photometry.

We are convinced that very good results would follow from similar co-operation between different nations with respect to lighthouse administration and the hygienic aspects of illumination. In both these subjects there are many doubtful points on which further information is needed, and both may be said to be of international importance. We think that the time has now arrived when it must be realized that individual effort cannot be relied upon to definitely solve these great questions. Individual research will, of course, always be of great value in order to open up new pathways and lead to new suggestions. Even in the past, however, the existence of societies has been necessary in order to render such work readily available, and cause it to be appreciated.

Holding these views, we are naturally anxious to give this magazine a truly international character. In this way we shall learn from each other, and, no doubt, gradually solve many of the difficult problems in illumination with which we are faced at the present time.

THE NATIONAL PHYSICAL LABORATORY.

We need not make any apology for discussing the important points brought out by the recent commission

on the future of the National Physical Laboratory. The work of this institution is rightly regarded as of national importance, and there is one section of its work—that relating to photometry and standards of light—which is attracting much attention at the present time, and is of special interest to us.

The National Physical Laboratory was formed partly with a view to carrying out valuable theoretical research work, but was also intended to act as a reference to whom recourse might be had in cases of dispute, for the purpose of verifying standards, or undertaking some special piece of industrial work which the appliances and experience at the service of the Laboratory enabled it to do better than could be done elsewhere.

It must be recognized that the National Physical Laboratory can only adequately fulfil the object for which it was created if it is properly supported. If the work of the Institution is to receive the respect which its position demands, the Institution ought certainly to be made as far as possible independent of the support of private individuals, and should possess such an equipment and staff as to cause its decisions to be accepted without cavil or dispute. It is clearly absurd to expect private firms and individuals to be content with contrary decisions when they feel that the facilities and experience at their own disposal are superior to anything at the Laboratory.

Above all, the laboratory ought to be definitely freed from the crippling necessity of undertaking work for the value of the remuneration. This necessity must tend to use up time which might preferably be devoted to research, and might tempt the laboratory to undertake work approaching the purely routine character. Indeed, for any laboratory to be really commercially successful, it must undertake a large proportion of such purely systematized and routine work. Hitherto the National Physical Laboratory has struggled heroically to carry out its functions, though crippled by want of the necessary funds. As we are in earnest in desiring to maintain in this country one institution capable of carrying out the beneficial work of the Reichsanstalt in Germany or the Bureau of Standards in the United States, for instance, let us at least endeavour to approach the support given to such institutions.

The work which the National Physical Laboratory is intended to carry out is shared between several separate institutions in Germany. In 1904 the cost of building and equipment of these institutions amounted in all to very nearly £400,000, and the combined annual grant to nearly £40,000. The staff contained upwards of 250 persons.

The cost of the newly installed equipment and building of the Bureau of Standards in the United States amounted to £115,000, and the annual grant is £19,000.

At the time to which these figures refer (see Report to British Assoc., Section A, 1904), the sum expended on the buildings of the National Physical Laboratory was given as £19,000, and the annual grant as £4,000, and the number of persons on the staff as 50. Since that date the annual grant has been increased, and for the years 1908 and 1909 to £7,000, while the capital grants and donations for building and equipment *from all sources*, amounts to about £46,000 (Minutes of Evidence before Commission, 1908, p. 95). The entire staff of the laboratory now amounts to about 95 persons.

The support given to the National Physical Laboratory, therefore, seems to us still far from sufficient. It must be remembered, too, that the German institutions are of much older date than our own institution, and have the advantages of accumulated experience. In our own case even greater expenditure might be necessary in order to

secure that the equipment and staff, as compared with that of various private establishments, should be correspondingly adequate. This is a case in which the Treasury might profitably grant support more nearly approaching that given to corresponding institutions in other countries. Far greater sums than that required are constantly expended on improvements the value of which may only become evident in the course of a generation. In the present instance we firmly believe that further expenditure would be amply and immediately repaid. Even under the present disadvantages the National Physical Laboratory has fully justified its existence, and the value to the nation of such an adequately supported centre of industrial research is beyond dispute.

Lighthouse Administration.

An interesting report has recently been issued by the Royal Commission dealing with the above subject. The report is mainly concerned with the details of administration of the boards controlling the coast-illumination of the United Kingdom, though a large number of very important technical questions arose in the course of the evidence given before the Commission.

At present the lighting of this country is under the control of three separate boards—the Trinity House authorities, the Commissioners of Northern Lighthouses, and the Commissioners of Lights—who are responsible for the lighthouses, &c., in England and Wales, Scotland, and Ireland respectively. Having found that the present administration is on the whole satisfactory, the Commission does not propose to alter the existing arrangements materially, and has only varied certain details, in order to promote freer intercourse and co-operation between the various boards.

No doubt there are good reasons for not yet attempting to place all the arrangements under one central authority, though we are given to understand that such a course may be adopted in the future. To us the value of international co-operation on such a subject seems very clear, and we hope that an official attempt at such co-operation will be made.

In this case there need be no feeling of mutual distrust or rivalry. There can be little doubt that different countries might learn much from each other by mutual discussion and experiment. Certainly, bearing in mind the immense annual expenditure in this department, the need for constant experiment, with the object of producing more efficient results and reducing cost of maintenance, is evident. We regret to note that, according to some of the evidence, there is a disposition to grudge the money necessary for such experiments. Here, surely, is an instance in which co-operation, in the form of sharing the cost of such researches, of mutual value, might prove beneficial.

Then, again, there must surely be countless cases where simplicity and convenience would follow the adoption of some common basis of action. One of the witnesses, indeed, expressly stated that the method of rating lights in France was not the same as in this country, and it is quite possible that similar differences of method exist in other countries. We really think that 'The Illuminating Engineer' is unusually favourably placed from this point of view, partly because of its impartiality of outlook on different illuminants, and also because of the international character of the magazine.

The Hygienic Aspects of Lighting.

Our present number includes an interesting article from the pen of Dr. Rideal, in which the results of his recent investigations into the hygienic aspects of gas and electric lighting are summarized.

Valuable as such researches are, up to a certain point, we cannot but feel that the question which Dr. Rideal

has attempted to solve is too wide to be adequately dealt with by a single individual. The views expressed on the subject by different authorities are in themselves frequently so conflicting, and the results of a series of experiments depend so much on the exact circumstances under which they are made, that even the impartial observer must remain in considerable doubt as to whether they are applicable to the particular conditions in which he is interested.

To meet with general recognition, therefore, any research of this nature ought to be backed by such a weight of impartial and authoritative evidence as to be absolutely convincing. It must also enter into the exact varieties of circumstances which actually occur under practical conditions, study the effect, and deal with all the many important factors included under the heading of "Hygienic Aspects of Illumination." We note that further experiments on the subject are now to be undertaken by Dr. Wade, who has received for that purpose a special grant from the Local Government Board. This is satisfactory, inasmuch as such experiments receive definite Government recognition; but to our mind this research can only be done satisfactorily by means of a Commission representing the different lighting interests, and assisted by the most eminent authorities, and in touch with a very extensive and prolonged series of tests; these tests will have to be conducted on certain definite lines to be agreed upon beforehand.

There are other important questions, such as the influence upon sight of colour and intrinsic brilliancy of illuminants now in use, on which no really authoritative data are available, and we hope that such an investigation will receive due consideration.

We desire, in short, a complete investigation into *all* the factors of importance from a hygienic point of view, undertaken by eminent authorities on the various aspects dealt with, and backed by the necessary Government support.

The Coming Municipal Exhibition.

The first Municipal and Public Health Exhibition is to be held at the Agricultural Hall from the 1st till the 12th of May in the present year. As will be seen from the notice printed elsewhere in this number, the subject of public lighting will receive special attention.

The opportunity of interesting those connected with municipal matters, seems to us an exceptionally good one. An immense sum of money is spent annually in public lighting, and it can scarcely be doubted that the results achieved might often be very materially improved.

It is therefore proposed to gather together illustrations of lighting by all the different illuminants, to exhibit photometrical apparatus of different kinds, and to explain their action by a series of short lectures by various authorities on the subject.

There is one feature in the exhibition to which we would direct special attention. The display will be conducted on an absolutely impartial basis. Opportunity will be granted to those who prefer to do so to exhibit their own apparatus, and such demonstrations of their action as are given will be carried out with the object of stimulating interest in the subject, and without any intention of comparing one instrument or system of illumination unfavourably against another.

This is, we believe, the first occasion on which an exhibition has been held devoted to illumination in general, and not merely to the display of any particular branch. We certainly hope that all who are in a position to do so will come forward and assist the honorary Advisory Committee in their enterprising effort.

Leon Gaster.

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 185.)

Theoretical Examples of Distribution.

By the means of the cosine law, and of the foregoing table, the illumination which will be produced by any given arrangement of lights may be determined. The principal object of my original paper was to attempt to enable engineers to predetermine, specify for, and provide a definite illumination. While it failed to be utilized in this way to any appreciable extent, other writers have from time to time calculated and published similar curves. Engineers may have considered these too laborious to apply in practical cases, and the illumination of streets, railway stations, &c., has been for the most part carried out either by adding to the number or to the power of the lights until the illumination was sufficient, or by trying experiments with lamps at various heights and distances. One excuse for this unscientific procedure was that in general nobody knew how much illumination was wanted.

The curve given on Fig. 9, and the table of values of cosine^3 θ, enable the curves for the combined effect of a number of lamps to be determined by the simple addition of ordinates. The curves given in Figs. 10 to 14 assume that the candle-power of each lamp is the same in all directions. They give the component and resultant curves for four different arrangements. The first, Fig. 10, represents the distribution of illumination on the ground due to a row of lamps at a distance apart equal to their height from the ground. The dotted lines are the cosine^3 curves, and the tails of the curves of the more remote lamps appear. The first full line shows the resultant illumination due to two lamps, and the next one above, a symmetrical portion being given, represents the illumination due to three lamps. The other lines similarly show the additional effect of more remote lamps. The horizontal scale is one of distances along the ground; the ordinates give illumination in an arbitrary unit, being the illumination which would be found below one lamp alone, if there were no shadow. It may be observed (but no one who is thinking of using the method should be alarmed by the statement) that the illumination at the maximum is 1 + twice the cubes

of the cosines of the angles whose tangents are 1, 2, 3, 4, &c., and is 1·978 when there are four lamps on each side. The minimum illumination is equal to twice the cube of the cosines of the angles whose tangents are

The next arrangement, Fig. 11, is that of lamps placed at a distance apart equal to twice their height. The dottted lines, as before, are the curves of the separate lamps, and the full lines the resultants. The maxi-

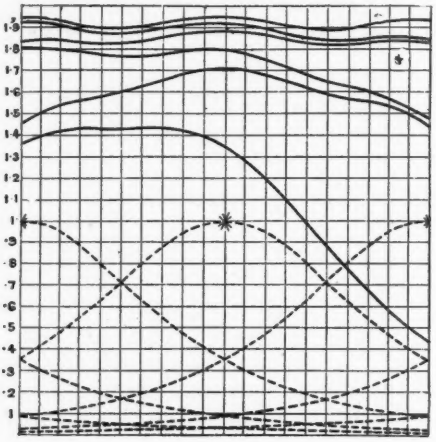


FIG. 10.—Resultant illumination due to lights at a distance apart equal to their height.

0·5, 1·5, 2·5, 3·5, &c., and is equal to 1·932 for five lamps. The resultant curve is practically symmetrical about a horizontal line, and the mean illumination may be taken as the arithmetical mean of the values. It is

mum illumination is 1·219, being twice the cubes of the cosines of angles whose tangents are 2, 4, 6, 8, and the minimum is 0·7836, being twice the cubes of the cosines of the angles whose tangents are 1, 3, 5, 7. The minimum is 35·8 per

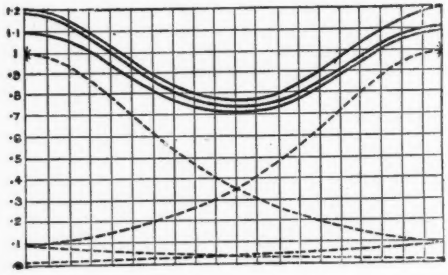


FIG. 11.—Resultant illumination due to lights at a distance apart equal to twice their height.

hardly necessary to point out that the eye could scarcely detect any variation in the illumination of the ground along the line of such a row of lamps, the difference being only 2¼ per cent.

cent. less than the maximum. The mean is practically unity. In the next arrangement, Fig. 12, the distance is three times the height. The maximum is 1·073, and the minimum is

0.362, being 63.8 per cent. less than the maximum. This variation is, of course, very marked, but is not nearly so apparent to the eye as is indicated by the curves. The last example, Fig. 13, is a common arrangement in street lighting, the distance apart being six times the height of the lamps from the ground. The maximum is 1·01, and the minimum is 0·0632, and the variation 93·7 per cent. The additional effect of only one lamp on each side has been considered. It is somewhat doubtful whether the mean illumination in these last two cases is a quantity worth considering, since the effect of such an illumination produced by a considerable number of smaller lamps, closer together, and approximating to that mean, would be very different.

The light of an ordinary continuous current arc lamp is emitted in a well-defined manner, and when used with a clear glass globe or lantern, may be taken as the worst case of non-uniform candle-power. Fig. 14 gives a curve showing the variation in candle-power, and the resultant illumination produced. With angles of incidence from 0° to about 55° the light is more or less obstructed by the lower carbon.* Beyond 55° the light follows a regular law, but not that of the cosine cubed, for the light is not emitted from a point or (in the case under consideration, that of the ordinary arc) from a flame, but from the horizontal tip or crater of the upper carbon. The projected area of this disc, as seen from any direction, varies as the cosine of the angle. The cosine being thus introduced for the fourth time, the illumination beyond 55° incidence varies as the fourth power of the cosine. The whole curve of cosine^4 θ is given in Fig. 14 as far as a point $2\frac{1}{2}$ times the height of the lamp. The part

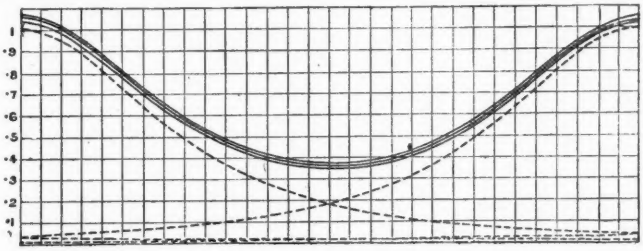


FIG. 12.—Resultant illumination due to lights at a distance apart equal to three times their height.

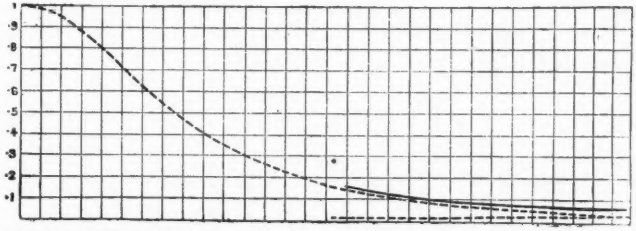


FIG. 13.—Resultant illumination due to lights at a distance apart equal to six times their height.

Two practical modifications must be considered with regard to these results: one is the non-uniformity of candle-power in different directions, due, in some cases, to the shadow of the gas burner or the frame of the lamp, or to the shadow of the lower carbon of an arc lamp; the other is the reflection of neighbouring walls.

* See Trotter, *Journal Inst. Elec. Engrs.*, vol. xxi.

between 55° and 0° is dotted. The total light or flux is π, and a right-angled cone contains half the flux.

In the foregoing curves (Figs. 9 to 14) the height of the lamp and the maximum illumination have both been taken as unity. This is an arbitrary convention, and is useful mainly in enabling the curves to be compared. When, owing to non-uniform distribution of the light, the maximum illumination does not occur below the lamp, this convention fails; but it is possible to retain the relation between the vertical and the horizontal scales by considering the illumination at some distance from the lamp. At angles of incidence greater than about 55 degrees, it has been already shown a straight line, and the typical curves (Figs. 10 to 14) show the results only in the line of the lamps. The next step is to consider the general distribution in plan. For this purpose lines or contours of equal illumination may be calculated. These correspond to the contour lines on maps, which show equal elevations. The calculation of these contours has been supposed to be laborious and intricate. There are generally difficult and tedious ways of performing any calculation, and certain people will delight in such methods. The following curves (Fig. 17) were drawn with no geometrical or even arithmetical calculations. A number of circles having as radii the tangent of the round num-

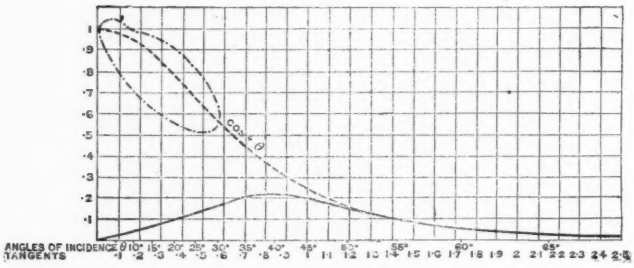


FIG. 14.

— · — · — · — Candle-power curve of arc-lamp.
— — — — Curve of $\cos^4\theta$.
——— Illumination curve for arc-lamp.

that the illumination from an arc lamp on a horizontal plane varies as the fourth power of the cosine. The fourth power of the cosine of 45 degrees is 0·25. If, then, the height of the lamp be set off on the same scale of feet as the horizontal measurements, and if it be assumed that the maximum illumination measured on a vertical scale be represented by a height equal to 0·25 of the height of the lamp, illumination curves of different kinds of lamps may be plotted together for comparison. Fig. 14 was constructed in this way. The flatness of this curve is rather a disadvantage.

Distribution over a Plane.—The foregoing considerations relate only to the distribution of illumination along

bers of the cubes of the cosines, taken from Table I., were drawn with thick black lines. The length of the radii are the lengths of the horizontal lines in Fig. 9 intercepted between the curve and the zero ordinate, or the last vertical line on the left.

One set was drawn on ordinary paper and another on tracing paper. Each circle was boldly numbered along a radius, with a maximum at the centre, 100. One sheet was laid over each other, and was adjusted with the centres, that is the lamps, at the required distance apart, remembering that tangent 1 is equal to the height of the lamp above the ground, and a blank sheet of tracing paper was laid over all.

Fig. 15 shows, for the sake of clearness, portions only of two sets of circles. The lamps are at a distance apart equal to four times the height of each. The tangent of the angle of incidence at the point midway between the lamps is 2. The angle of incidence is 63 degrees 27 minutes, and the cube of the cosine is 0·0893. The intersection of the circles give a number of quadrilateral figures. Lines are drawn by free-hand from corner to corner through these quadrilaterals, and these are the contours required. Everywhere along the circle numbered 6 the illumination due to each lamp separately is 0·6 of the maximum illumination below the lamp. At the point when the two 6 circles cross the illumination will evidently be 12; and where circle 8 crosses circle 4 the illumination will be 12. Thus the values

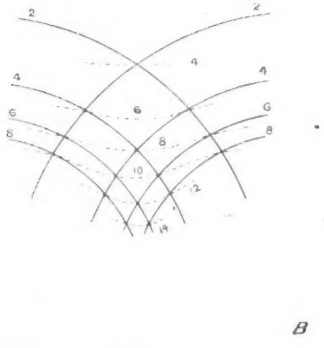


Fig. 15.

of the contours can be found. Where the circles do not intersect a little judgment is required, and this may be assisted by the following method.

Mark off two scales of radii along the edges of two strips of paper and pin them on to a sheet at points representing the lamps at the desired distance apart, as in Fig. 16, starting, say, with 6 set against 6, make a dot at the intersection. Move one strip clockwise and the other counter-clockwise until the next pair of divisions meet, make another dot, and continue, observing from time to time that the

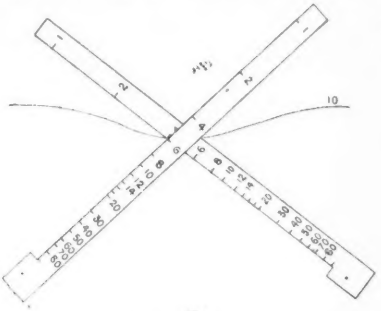


Fig. 16.

sum of the numbers remains constant. Only one quarter of the whole system need be drawn when two lamps are concerned, and this can be repeated four times by tracing. It is, in general, better to find the contours of two lamps first, and to combine a third by the first method. The contours for three lamps may be found by using three strips, but a good deal of mental arithmetic is needed to adjust them so that the sum may be constant. The illumination of a number of points regularly spaced or otherwise may be found by using three or four or more radial strips, and these may be prepared to represent lamps of different candle-power or placed at different heights. The strips are adjusted to intersect at any desired point, and the readings on the scales at this point are added together and written against the point. Contours may then be drawn by hand and eye, as in ordinary map work, and at any doubtful point the contour may be easily verified by bringing the scales to intersect.

(To be continued.)

The Globe Photometer in Practical Photometry.

By Dr. L. Bloch.

The Globe Photometer, a simple instrument intended for the measurement of mean spherical candle-power, was described by Prof. R. Ulbricht as long as eight years ago in a contribution to the *Electrotechnische Zeitschrift* (1900, p. 595).

However, it did not come into very general use until the year 1905, when the instrument was investigated simultaneously in several laboratories, and the favourable experiences of those undertaking the experiments were described in several subsequent contributions to the above-mentioned journal.* Since that time the use of the Globe Photometer has rapidly extended in Germany, especially since the Photometrical Commission of the German Institution of Electrical Engineers (Verband Deutscher Elektrotechniker) recommended its use for the photometry of arc lamps.

At the present time the Globe Photometer occurs in almost all German photometrical laboratories, and has proved itself of great value in the hands of capable workers. On the other hand, the instrument does not seem to have found very extended use in England or America. This is the more surprising, because it is in these very countries that a lively interest in illumination and questions of light measurement has recently been manifested, as is shown by the organization of a Society, and of a journal devoted solely to problems of this nature. Moreover, in England and America greater weight is attached to the value of the mean spherical candle-power than in Germany, and it is for the measurement of this particular quantity that the Globe Photometer is specially and pre-eminently adapted. It may, therefore, not be out of place in the present article to consider the Globe Photometer in the light of its application to practical photometry.

Besides the Ulbricht Globe Photometer mention may be made of the Lumenmeter of Blondel and the Matthews Integrating Photometer, which are also intended for the measurement of mean spherical candle-power. Both the latter instruments, however, only enable the mean candle-power in one meridian plane of the source of light investigated to be obtained by a single measurement. This value is only identical with the mean spherical candle-power when we have to do with a source of light which is perfectly symmetrical; that is to say, a source of light which yields the same intensity in all directions at a given angle to the vertical. Such a source of light is only approached by the Nernst lamp with a vertical glower, or a glow-lamp with a single vertical filament. Ordinary glow-lamps certainly cannot be regarded as perfectly symmetrical sources, and their intensity must either be measured in a series of different directions, or the lamps must be rotated during the experiment. Preferably, in order to obtain the mean spherical candle-power of glow-lamps with the Blondel or Matthews photometer we must rotate the lamps about the vertical axis by the aid of an apparatus similar to that employed for the determination of mean horizontal candle-power. Arc lamps also do not, as a rule, distribute their light uniformly,

* *Electrotechnische Zeitschrift* :—

Ulbricht	1905, p. 512.
	1906, p. 50 and 803.
Bloch	1905, pp. 1047 and 1074.
	1906, p. 63.
Consepius,	1906, p. 468.
Monasch	1906, p. 669, 695, 803.

and, therefore, their intensity must be measured in at least two perpendicular directions, if the above types of photometers are employed.

On the other hand the Globe Photometer enables the mean spherical candle-power of a source to be determined by means of a single measurement, even when the distribution of light from this source is very far from being symmetrical. In addition to this it is essentially simpler and cheaper to construct than the photometers of Blondel and Matthews. It is, moreover, easier to use than these instruments, and does not require the same expert manipulation on the part of the experimenter. In the two types of photometer referred to, for instance, it is essential that the sources of light to be tested should be situated exactly in the centre of the apparatus; in the case of the Globe Photometer, on the other hand, it is theoretically entirely immaterial, and, from a practical point of view, very nearly so, what the particular position of the source of light within the globe may be. Also the Globe Photometer enables the mean hemispherical candle-power to be obtained in a particularly simple fashion, and this quality is, of course, of considerable practical importance.

The proof of the correctness of the principle on which the Globe Photometer depends need not be repeated here. The correctness of this principle has been satisfactorily demonstrated both experimentally and theoretically in the contributions mentioned above, to which reference may be made if further details are required. For the present we will only consider the practical application of the results referred to.

Suppose that the source of light "L" is placed in any particular position in the interior of the hollow sphere, the inner surface of which is coated with a white diffusely reflecting varnish. Then the illumination of any particular point, "F," from the surface of the globe is proportional to the mean spherical candle-power of this source, if all the light radiating from this source remains, and is reflected to and fro within the globe. Thus the illumination at the point F is a measure of the intensity of this diffusely reflected light, it being understood that the direct rays from the source of light are screened from the point F by means of a suitable screen, B, as shown in Fig. 1.

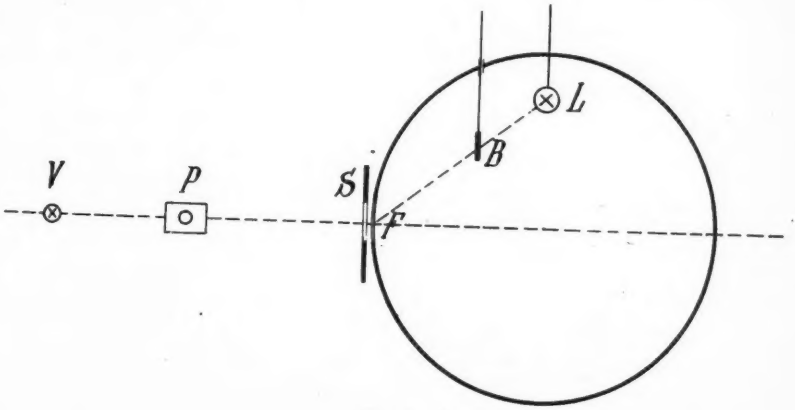


FIG. 1.

On the other hand, we may not use a complete globe, but one with an aperture at the top of the upper hemisphere, as shown in Fig. 2, the source of light being situated in the plane of the small circle of the sphere formed by this aperture. In this case all the light thrown in an upward direction

does not illuminate the interior of the globe, and therefore the illumination of the inner surface of the globe is proportional to the mean lower hemispherical candle-power of the source. Here, again, the direct light is screened from the window F by means of the screen B.

In utilizing the Globe Photometer it is, therefore, only necessary to measure the illumination at a single point F, at the surface of the sphere. F may be situated at any desired point on the surface, but from considerations of convenience it is usual to select a point situated on the equator of the globe. Here a circular opening is made, the diameter of which varies, according to the size of the globe, from about 4 to 10 centimetres. If one utilizes the globe in conjunction with the ordinary photometrical bench, an opal glass screen is inserted into this orifice, and the brightness of this screen is compared with a suitable comparison lamp by means of the photometer P, as shown in Fig. 1. The value so obtained is proportional to the illumination at the point F of the inner surface of the sphere, and, therefore, also proportional to the mean spherical candle-power of the source of light under test. On the other hand, a photometer of a variety intended for measurements of illumination, as, for example, the Weber instrument, may be employed. In this case the photometer can be applied to the aperture in the globe, and the illumination measured direct without the necessity for a diffusing glass screen (see Fig. 2). In this way the apparatus assumes a very convenient and practical form.

Measurements of a source of light with a globe photometer naturally only afford relative values, and to obtain the mean spherical candle-power these results must be multiplied by a suitable constant obtained by calibrating the photometer. For this purpose it is usual to employ some source of low mean spherical candle-power, preferably a standardized glow-lamp yielding about 25 to 50 candle-power, which is only used for a short time at a stretch, in order that this candle-power may remain constant for as great a length of time as possible. The mean spherical candle-power of such a standard glow-lamp is obtained by means of point measurements in the usual way.

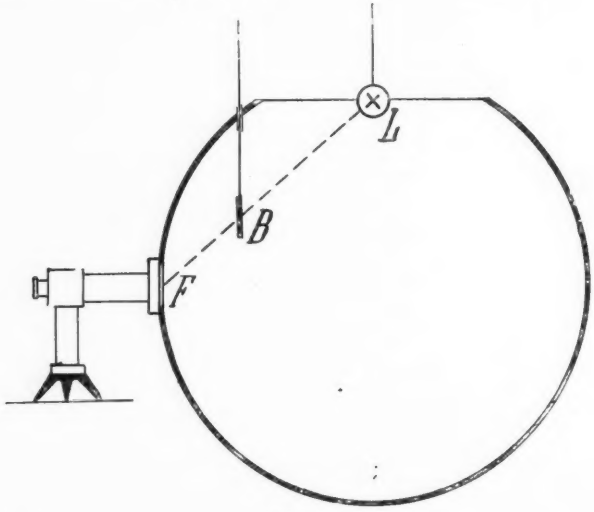


FIG. 2.

If, therefore, the source of light

under test in the Globe Photometer is replaced by a standard lamp, the comparison between its own mean spherical candle-power and the actual photometrical result enables us to calculate the desired constant. Instead of substituting a standard lamp for that under test we may adopt the proposal of Ulbricht, and place a standard lamp in the globe as well as the lamp under test, but in some other position, such as that shown in Fig. 3, the direct rays of the standard lamp being screened from the point F in the usual way.

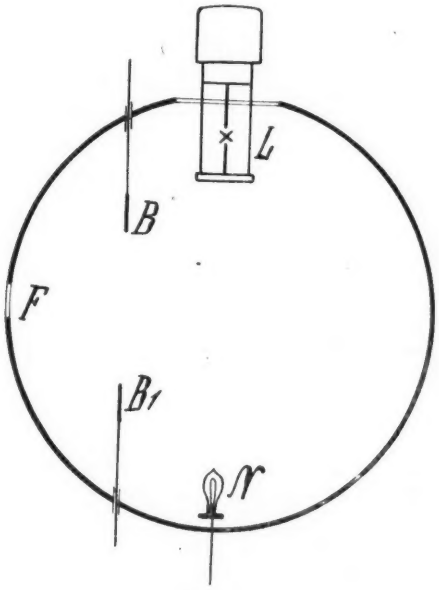


FIG. 3.

As the exact position of a light-source within the globe is immaterial, this arrangement enables us to carry out the calibration immediately after the experiments on the source of light to be examined, without it being necessary to remove the latter from the globe. All that is necessary is for each to be lighted in turn, and the corresponding measurements obtained.

When the constant of the globe has been obtained once and for all it should not alter, so long as the method of measurement and the coefficient of reflection of the inner coating of the globe remain the same. It is, however, preferable not to assume that this is the case, but to repeat the calibration periodically, so as to avoid possible sources of error, at intervals of time depending upon the degree of use to which the photometer is put.

The constant of the globe so obtained, is, however, applicable to measurements of sources of all varieties and intensities, and it is not necessary to determine this value anew for each variety of light experimented upon. Only in the case of sources possessing very extended radiating surface or bulky accessory apparatus will accuracy of the measurement be influenced. When it is desired to test a large number of sources of the same kind it is a good plan to first obtain the mean spherical candle-power of the type by point-to-point measurements on a single lamp, and then to calibrate the photometer by using this particular lamp. A value of the constant is thus obtained, which

holds good for all sources of light of this particular variety. But in the case of all ordinary photometrical measurements the requisite degree of accuracy is obtained by the use of a standard glow-lamp.

Fortunately the actual construction of the globe photometer is very simple. The apparatus consists essentially of a sphere constructed of zinc or iron plates, with several openings, and equipped with a suitable movable screen.

If the Globe Photometer is only intended for the measurement of glow-lamps, a diameter of the globe of 0·6 to 0·8 metres suffices. If intended for experiments on naked light arcs, or for those having but small globes, it is advisable to make use of a globe with a diameter of 1 to 1·5 metres. If, however, arc lamps having globes of all the sizes occurring in practice are to be tested, a diameter of 2 metres is necessary.

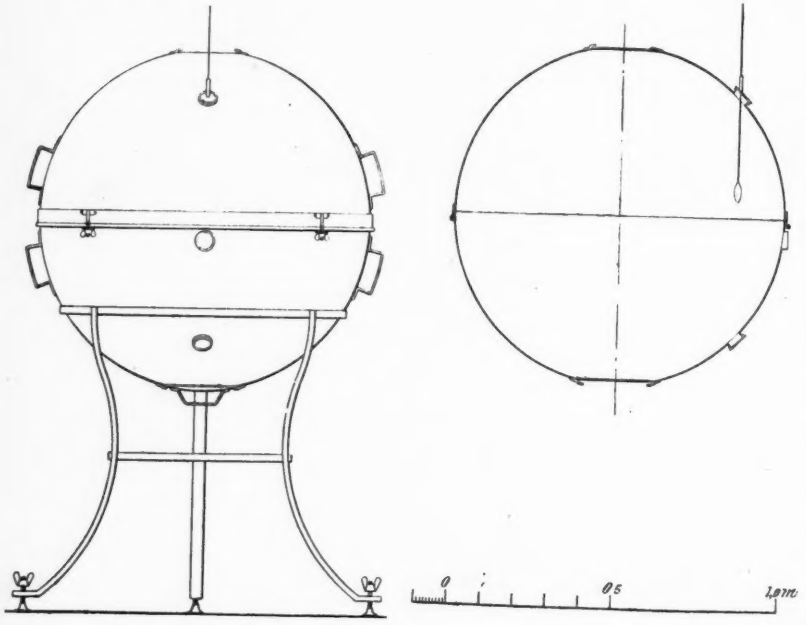


FIG. 4.

The upper aperture serves to enable sources of light to be lowered into the globe or to be removed from the apparatus to receive attention, and usually consists of a circular opening, which is 20 to 50 centimetres in diameter, according to the dimensions of the globe. As previously mentioned, there is also an opening at the side of the globe for the purpose of measuring the illumination, and there are also others which enable the observer to inspect the source of light while carrying out experiments upon it.

Globe photometers, having a diameter of even 2·5 and 3 metres, have also been constructed, and are in use at the present time. The choice of such great diameters arose from the desire to render the dimensions of the light source under test relatively small in comparison with those of the globe, and hence to reduce any sources of error due to the size of the lamp tested to a minimum. Yet it is doubtful whether there is any gain in accuracy by increasing the diameter beyond 2 metres. Certainly the original cost

of the photometer, and also the amount of space occupied by it, is undesirably increased. It must also be noted that very large globes cannot conveniently be employed for the measurement of glow-lamps of comparatively small candle-power, because the illumination at the observation opening becomes inconveniently low; this illumination is inversely proportional to the square of the diameter of the globe.

The writer has employed a photometer one metre in diameter for several years with very satisfactory results, both as regards accuracy and convenience of measurement. Fig. 4 shows a sketch of this instrument as previously described in the *Electrotechnische Zeitschrift* (1905, p. 1050). This globe is made of zinc plate 2 millimeters in thickness, the two halves of the globe being built up by pressure on a model, and subsequently connected together by suitable screws and wing-nuts. The upper and lower apertures of this globe are 20 to 25 centimetres respectively in diameter, both being provided with suitable covers fastening on the bayonet principle.

There are also three side apertures, each 5 centimetres in diameter, for the purpose of observation. The central aperture of these three serves for actual measurement of illumination, and the upper one enables the position of the screen within the globe to be adjusted; the lower aperture is used for this purpose in cases in which it is necessary to introduce a source of light from the base of the globe.

Fig. 5 shows a Globe Photometer 2 metres in diameter, previously described by Dr. Monasch (*E.T.Z.*, 1906, p. 670). This instrument is composed of 64 segments of sheet iron, which are bound together by flat strips. The globe is divisible into two sections. On the right hand we see the Weber photometer in position applied to the illuminated window.

The condition of the light-reflecting coating in the interior of the globe is of special importance. The more uniform and lasting is this coating, the greater will be the attainable accuracy, and the smaller any variation in the constant of the photometer in the course of time. In order that as great a percentage as possible of the light falling upon the interior of the globe may be reflected the coating must be composed of some pure white material. For this purpose barium sulphate or zinc-white may be used. By the use of either of these materials a coating can be obtained which reflects about 75 per cent. of the light falling upon it; but as the coefficient of barium sulphate is apt to alter under the influence of certain kinds of light, zinc-white seems to be best designed for this purpose. The coating so obtained must not only be white, but must present a dull, matt surface, without any sign of shininess. Otherwise, one does not obtain the true diffused reflection of the light which the theory of the instrument demands, and the coefficient of regular reflection enters into the problem. Moreover, the material employed for coating the interior of the globe should not contain too much of the fine glue solution, which is generally added in order to make the coating adhere. If the percentage of adhesive material added is too great the surface assumes a yellowish tinge.

The coating of the instrument gradually becomes darker with use, and this causes a corresponding alteration with the constant. So long as the darkness is uniformly distributed this has but little influence on the accuracy of measurement. If the darkness is very considerable, however, or is irregular, it is desirable to renew the light-reflecting coating. Under ordinary circumstances this will probably be necessary every six to eighteen months, according to the use to which the globe is put and the exact nature of the coating. The screen which serves to keep the direct rays of light from falling ~~from~~ the illuminated window may be simply constructed out of white cardboard. Its exact dimensions naturally depend upon the dimensions of the source of light tested. In the case of ordinary glow-lamps, and arc-lamps without globes, a diameter of about 5 centimetres generally suffices. The screen is provided with a white rod by means of which it can be mani-



FIG. 5.

PHOTOGRAPH OF GLOBE PHOTOMETER, 2 METRES IN DIAMETER.

pulated or placed in any desired position from one of the aperture windows in the side of the globe. One can easily judge whether the correct position of this screen has been obtained by looking at the source of light through coloured glasses, and observing whether any direct rays from the source of light are visible. This method, however, is not to be recommended, at all events, in the case of the person who is going to carry out the photometrical measurements himself, because it would certainly disturb his eyes in the subsequent measurements. It is more convenient to place a slip of white cardboard in front of the illuminated window, and to judge by the brightness of the illumination upon it when the correct position of the screen has been obtained.

As mentioned before, it is theoretically quite immaterial what the exact position of the source of light within the globe may be. Practically, however, it is preferable not to place the source of light in the exact centre of the globe, because the various bits of apparatus attached to the lamp must also be introduced into the globe with it, and will interfere with the accuracy of measurement; it is, therefore, better to place the source of light nearer the wall of the globe, and perhaps 10 or 20 centimetres from the aperture at which it is introduced. By so doing the mechanism of the arc lamp and suchlike inconvenient apparatus can be kept outside the globe.

The majority of sources of light will be introduced into the globe from the upper opening, but in the case of petroleum and alcohol lights, and many gas lamps it is often convenient to introduce the light through the lower opening. To facilitate this process it is desirable to support the globe in some form of framework in such a way that its lower point is not nearer than half a metre to the floor.

In order to measure the mean spherical candle-power, the knowledge of which is especially valuable in the case of many arc lights, inverted gas-lights, &c., the source of light must be situated exactly in the plane of the aperture at the top of the globe. Under these conditions all the light in the lower hemisphere passes into the globe, while that in the upper hemisphere, on the other hand, passes outside and is not measured. In the case of naked arc lamps, &c., and in other cases in which very great accuracy is not essential, one can judge this position very correctly by observing the border line between the light and shadow on the wall of the photometer-room. If this shadow line is situated at the exact height of the aperture of the globe from the floor, the position of the light source is correct. It is very convenient to mark out this correct height by a strip running round the whole of the room.

In the case of sources in which the radiating surface is more extensive, *e.g.*, glow-lamps and incandescent mantles, one must endeavour to arrange so that the centre of radiation of this light-giving surface is situated on the plane of the aperture. Where very great accuracy is desired we may determine this centre of radiation by the method of Ulbricht (*E.T.Z.*, 1906, p. 50, and 1907, p. 777).

In the case of measurements of mean hemispherical candle-power the determination of another constant for the photometer is necessary, and this can be obtained in the same manner as that described previously for the mean spherical candle-power. It is approximately double the value of the constant in the latter case.

In measurements involving the determination of mean hemispherical candle-power appreciably greater care is necessary than when determining the mean spherical candle-power. In the latter case, as previously mentioned, the exact position of the source of light within the globe does not very much matter, but in the former case small inaccuracies in situation of the light source causes very appreciable errors in the result. In many cases it is preferable to determine the mean spherical candle-power in the photometer, and to determine the mean hemispherical candle-power therefrom by the use of a reduction factor, obtained once and for all for the variety

of lamp under test. For instance, this factor approaches 1·85 to 1·95 in the case of the naked arc lamps, and 1·02 to 1·05 in the case of the majority of glow-lamps.

It may next be inquired for what kind of measurements is a Globe Photometer specially adapted. In this connexion, the measurement of light from arc lamps is worthy of special mention. The determination of polar curves of distribution of light and the deduction of mean spherical candle-power or mean hemispherical candle-power therefrom not only demands considerable expenditure of time, but also a very competent observer. But these quantities can be obtained direct by the use of the Globe Photometer by means of one or two single measurements. The influence of different currents or P.D.s, or certain varieties of carbons on the mean spherical candle-power of an arc lamp can be obtained in a very short time. Therefore the Globe Photometer is especially serviceable for the comparison of different kinds of carbons in the same lamp or different kinds of lamps with the same pair of carbons.

The necessity for this Photometer is not so striking in the case of measurements of the candle-power of glow-lamps, although it may be very serviceable in this connexion also. As yet measurements of the candle-power of glow-lamps are almost exclusively made in the horizontal direction. In such a case it is essential to measure the intensity in several different directions horizontally; otherwise irregularities in reflection and refraction from the glass bulb introduce very considerable errors into the results, even though the lamp itself may yield a very uniform distribution of light. Hence special mirror-appliances or arrangements for the purpose of rotating the glow-lamps have been devised in order to enable the mean horizontal candle-power to be obtained from a single measurement.

It is naturally desirable that when great numbers of glow-lamps are to be compared some standard method should be adopted, especially in order to be able to secure agreement between measurements from different sources. Therefore measurement by means of the Globe Photometer ought to receive precedence, because in this instrument the whole of the light given out by the lamp is taken account of. The mean spherical candle-power measured by the Globe Photometer can easily be converted into mean horizontal candle-power by the use of a suitable reduction factor. This factor can be obtained once and for all for the various types of lamps in question by measurement of the mean spherical candle-power in the Globe Photometer and the mean horizontal candle-power by one of the special types of apparatus previously referred to; both candle-powers can also be obtained by point-to-point measurement. The reduction factor is then the quotient of the mean spherical by the mean horizontal candle-power. In the case of the majority of glow-lamps this factor is intermediate in value between 0·76 and 0·82. When great accuracy is not essential we may take this reduction factor as 0·78.

As well as glow lamps and arc lamps other sources of light can be very quickly and easily tested in the Globe Photometer, and the dimensions of lamps capable of being so tested is only limited by the diameter of the globe. It need not be feared that the measurement of the light from lamps burning combustible substances will be prejudiced by alterations in the state of the atmosphere in the globe, because the various openings in the globe provide abundant ventilation. Experiments on this point are, however, being carried out by the Institution of Gas Engineers in Germany, and no doubt the results will be available very shortly.

Now that the practical value of the Globe Photometer is thoroughly appreciated in photometrical laboratories in Germany, it may confidently be predicted that this instrument will receive the attention it deserves in other countries.

A New Form of Photometer for the Comparison of Sources of Light which Differ in Colour.

By W. Biegon von Czudnochowski.

One of the oldest and most simply constructed of photometrical instruments is the so-called "Lambert" or "Lambert-Rumford" photometer. This consists essentially of a simple vertical rod, shadows of which are thrown on a white ground by the two sources of light to be compared

The distances of these two lights are then adjusted so that the two shadows appear equally bright. It is, however, well known that it is very difficult to compare sources of light which differ in colour by a method depending upon the principle of "equality of brightness." In this case the different colours of the shadows renders this method difficult of application, and, as the author has shown elsewhere, the Lambert - Rumford photometer ought, strictly speaking, to be termed "A Contrast Photometer." because we really attempt to judge balance by the equality of contrast of the shadows against the white background of the screen. The sensitiveness of this simple photometer is not very great, even when a suitable transparent screen, enclosed in a box so as to avoid the possibilty of diffused light reaching the screen, is used. It seems possible, however, to develop this apparatus so as to obtain much better results.

Suppose that, instead of a single shadow, we utilize a number of equidistant shadows all vertical, parallel to one another, and in the same plane; then, if the two sources of light producing these are in the same horizontal plane, we can produce a series of equidistant shadow lines on the screen, of which those corresponding to the numbers 1, 3, 5, 7, &c., have the colour of the first of the two lights to be compared, and those corresponding to the numbers 2, 4, 6, 8, &c., the colour of the second; otherwise the conditions are unaltered.

We have, however, an entirely different result if we use two separate gratings composed of parallel wires and crossing at angles of 45 degrees to the horizon. In this case two intersecting shadows are formed on the screen, and the points of intersection of the patterns, being illuminated by neither of the two sources, appears much darker than the rest, as is shown in Fig. 1.

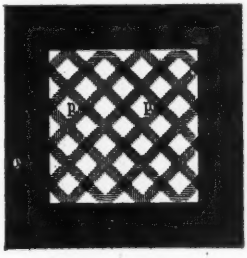


Fig. 1.

By this means a new system of comparison is available; we form our judgment not only by the contrast between the shadow pattern and the white background, but also between the shadow pattern and the dark points of intersection; but the method may be further developed.

When we project the image of a solid object on to a semi-transparent screen, the image appears sharply defined when our direction of vision is perpendicular to the screen, but becomes indistinct when viewed obliquely; this is a natural consequence of the semi-transparency of the screen. We can now arrange that the direction

of the rays coming from the *left* hand light source coincides with the direction of vision of the *right* eye, and vice versâ. Thus an image formed by the left hand sources appears sharp to the right eye, while, conversely, an image formed by the right hand source only appears distinct to the left eye. This gives rise to a stereoscopic effect, and one observes a system of black points, apparently free, against a background formed by the pattern.

In order that these considerations may hold good certain conditions must be realized.

Fig. 2 represents a horizontal sectional view of the arrangement.

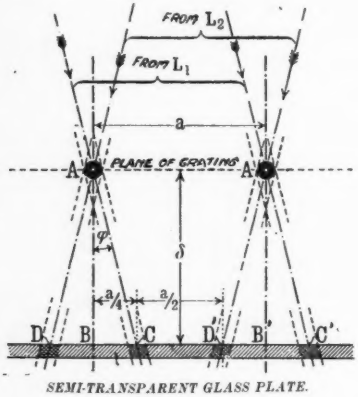


FIG. 2.

Let " a " be the distance AA between the two wires of the grating, *i.e.*, the diagonal of the mesh formed by crossing the two patterns. Let " d " be the distance AB between the grating and the diffusing glass plate. Then if the light sources be placed symmetrically, the distance between two adjacent shadow-lines DC, CD', C'D', is $\frac{a}{2}$, and similarly $BC = \frac{a}{4}$.

Hence if ϕ be the angle of incidence of the ray forming the extreme edge of the shadow, we have :—

$$\tan.\ \phi = \frac{BC}{AB} = \frac{a}{4d} \quad \ldots\ldots\ldots (1)$$

A must be distant from the eye of the observer the smallest distance of distinct vision (*i.e.*, about 25 centimetres) = " n," say. Then taking the distance between a normal pair of eyes as a_o = 6·5 centimetres, we have also :—

$$\tan.\ \phi = \frac{a_o}{2n} \quad \ldots\ldots\ldots\ldots (2)$$

From (1) and (2) we obtain $a = d \cdot \frac{2a_o}{n}$ (3)

Thus, given " d," " a_o," and " n," we can determine " a." Also, as the angle of intersection of the two gratings is in this case 45 degrees, the distance between two wires on the grating becomes $\sqrt{2}$. Hence, if we select the value 1 centimetre, for " d," the above distance becomes 3·68 millimetres. Actually, in the experiments of the author, " k " was 2·25 mm., and hence the exact value of " d " worked out to 6·12 mm.

One difficulty experienced in these investigations was the construction of a suitable form of grating. The ordinary variety of wire-gauze is not satisfactory for the purpose in view, because of the wavy character of the wire. The individual strands cross and recross, first underneath and then over each other. Hence, if the diameter of the individual wires is 0·5 mm., the grating as a whole has a thickness of 1 millimetre, which is too great compared with " d." The grating is preferably made by a method similar to that employed in the manufacture of lead plates for accumulators; it might, with advantage, be stamped out of thin sheet.

It is well known that, in accordance with the " Purkinje effect," our eyes are incapable of perceiving colour, if the intensity of the coloured light is too low. Under these circumstances all objects appear of a ghostly grey. This can be explained by the physiological structure of the eye, and is due to the fact that certain organs on the retina, with which are connected the functions of perceiving colour, are insensitive at these low illuminations. When the introduction of the arc light drew attention to the difficulty of comparing sources of light differing in colour, Allard and Gladstone, in 1881, were led to suggest that sources

of light might be compared at such distances from the photometer, as to cause the illumination of the photometric surfaces to fall below that value at which the colour-sense disappears.

The author is not aware of this method having actually found practical application. The process dealt with in this article, however, seems to admit of the production of a colourless field,

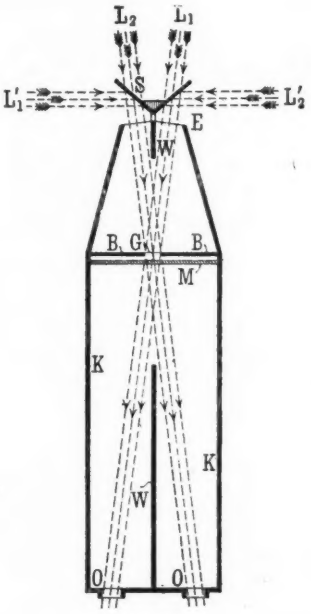


FIG. 3.

without the necessity for utilising a low order of illumination. Instead of two fields on the photometer we have now the two shadow patterns appearing grey on a white background with black intersections, but if either of the light sources is moved very sensibly out of balance one of the patterns becomes coloured.

The utilization of the stereoscopic effect is of great consequence, the method being somewhat similar to that utilized in the "Anaglyphs" invented by Duros du Hauron. According to this method, two stereo-photographs of an object are taken, and the corresponding positives are prepared, which are reproduced, say, in red and blue. These are viewed by the observer through a pair of spectacles, one lens being coloured red and the other blue, so that one eye sees only the blue image and the other only the red image, exactly as in the stereoscope, and thus the two superimposed images give rise to a single impression.

We have thus a stereoscopic effect analogous to that utilised in the photometer described in this article.

Finally, the general nature of the optical system of the shadow-grating-photometer is shown in Fig. 3.

KK is a light-tight box, blackened on the inside, with two circular openings, O, O. BB is a diaphram into the centre of which is let the small grating G. Slightly in front of B is situated the diffusing glass plate M; the screen WW serves to divide the box into the left and right portions.

L1, L2 are the light sources to be compared. In order that the apparatus may be used on the ordinary type of photometer bench two mirrors, shown at S in the diagram, can be utilized; then, if the lights are placed at L_1, L_2, the two beams of light converge as before.

The advantages of the form of photometer described in this article consist in its simplicity, its great sensitiveness, and its value for the comparison of the various modern illuminants, such as the flame arcs, enclosed arcs, &c., which differ very considerably among themselves in spectral composition.

The necessity for some such photometer is certainly much greater than in the past when the illuminants in existence resembled each other very closely in colour, and the difficulties referred to did not arise in practical photometry.

The Chicago Electrical Trades Exhibition.

An exhibition under the above title was held at Chicago from January 15th to 25th of the present year. The electrical lighting of the exhibits and of the whole exhibition generally was of a special character, and, through the courtesy of the *Electrical Review* of New York, we are enabled to include some illustrations of the most interesting features of the arrangements referred to.

It is stated that during this exhibition light was used on a more lavish scale than had ever been the case under similar circumstances before. Judging from the effects of such lavish lighting in some displays in this country, one would be inclined to exercise caution in regarding this as an advantage. It is common knowledge that in many such instances a great deal of light is spent, with the result that the building as a whole becomes a blaze of light, which, so far from producing artistic effects, is wearisome to a degree.

It is, however, satisfactory to learn that in the present instance the general scheme of illumination was devised by a firm of architects in co-operation with illuminating engineers with special reference to the production of effects pleasing from the æsthetic standpoint. The chief features of the general scheme of illumination seem to have involved the use of festoons of lamps and chandeliers carrying 275 lights apiece. Some of these occur in Figs. 1 and 2.

The illumination of the various stalls demanded special arrangements, but, in general, efforts were made to tone down the great brightness of individual sources of light by the use of suitable shades, &c. Special mention may be made of the exhibit of the National Electric Lamp Association, where a series of 40 and 60 watt tungsten lamps, including 300 40 watt tungsten lamps equipped with special holophane reflectors, were shown; the pleasing effect of the combination should induce other lamp-makers to follow suit. Fig. 1 shows a stall illuminated by various forms of holophane globes and reflectors. The main sources of light are placed within holophane globes, while 132 of the new bowl-type reflectors are mounted round the sides of the stall.

Naturally illuminated signs were in evidence, and there were also some attempts to bring home special points in illumination. For instance, arrangements were made to show the difference between the appearance of coloured materials when illuminated by the carbon filament and the osram lamps respectively. For this purpose a stall, which could be illuminated by both systems, was equipped with pictures rich in bluish and greenish tints, and also specially decorated with materials in delicate shades of colour. Each variety of light was switched on in turn, and the improvement in colours under the osram light, which, of course, represents a closer resemblance to daylight, was demonstrated.

One company arranged to fit up an "electric home," where actual furnished rooms illuminated by various types of holophane and other types of shades and reflectors, and the newest fixture designs were exhibited.

An exhibition presents an excellent opportunity of exhibiting special lighting effects, and educating the public to appreciate the difference between bad and good illumination.

Certainly the advantage to be gained by the company that studies the needs of the consumer in this respect, and is willing to take some trouble to lead him to appreciate this distinction, are well worth consideration.

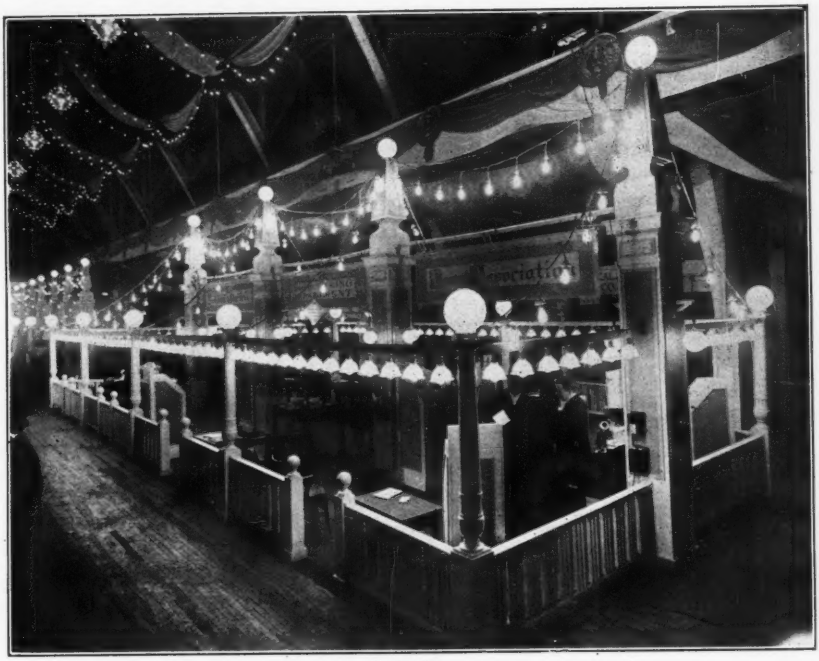


FIG. 1.



FIG. 2.

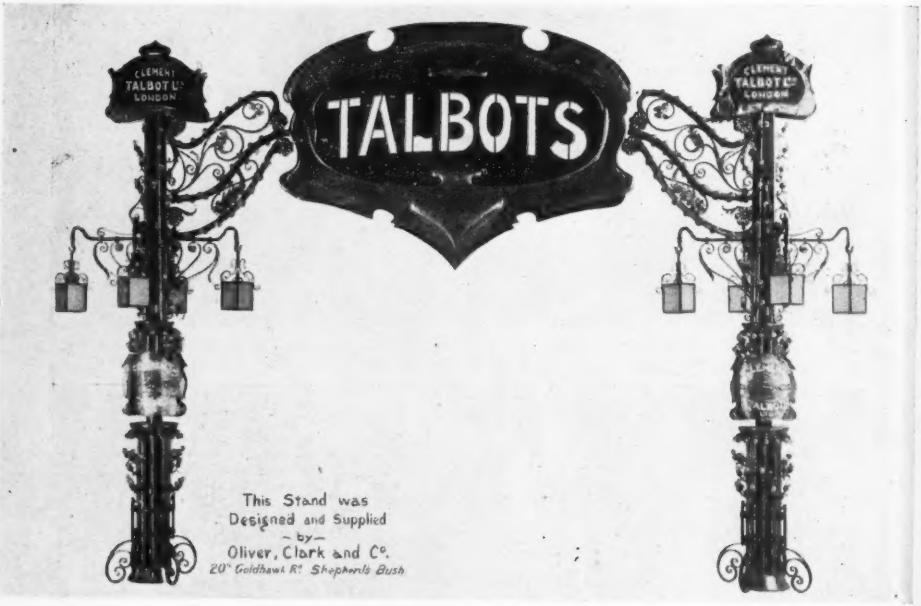
EXHIBITS AT THE RECENT CHICAGO ELECTRICAL EXHIBITION.

Electrically Lighted Signs at the Olympia Motor Exhibition.

THE CLEMENT-TALBOT STAND.

(From a Correspondent.)

THE question of the best methods of illuminating notices, &c., is attracting no little attention at the present moment, and a description of the electrically illuminated sign shown in the illustration, one of the many tastefully illuminated devices at a recent Olympia motor exhibition, should therefore be of interest.



The framework of the stand was constructed of wrought iron and copper hand work throughout.

On this frame were mounted one large central shield and four smaller similar shields at top and bottom of the two pillars.

The lighting of these shields was carried out as follows :—

The large central shield was illuminated by thirty internally placed 16 C.P., 220 volt lamps, while the two top shields and the two lower shields received ten and fifteen 16 C.P. lamps respectively.

On each pillar four brackets arranged to carry four illuminated lanterns were arranged, each lantern containing four Osram 50 C.P., 110 volt lamps, wired two in series. The rest of the illumination of the stand was carried out by means of 8 C.P. 44 volt lamps connected 5 in series.

Other arrangements were necessary in order to illuminate the various trophies. In all 44 distinct circuits controlling the different lamps were utilized.

It is interesting to note that as much as half a mile of 3/25 wire was used for the wiring of the small series lamps, and 2½ miles for all purposes. Yet all this wire was completely concealed.

Modern Methods of Illuminating Display Windows.

A Critical Description of the Recent "Augur" Exhibition in Berlin.

By Dr. Karl Stockhausen.

One of the most interesting of the special exhibits at the recent "Augur" (Ausstellung Umfassend Gesellschafts-austattung und Reklame) Exhibition, which has been held in Berlin under the auspices of the society of special industries from the 12th to the 14th of February, was certainly that devoted to illumination. This exhibit was confined exclusively to the illumination of display windows, the arrangements being designed to answer the question, *What is the best way of illuminating a modern show window in at once. the cheapest and most effective manner?*

Seldom—one might say never—has a similar opportunity been afforded, both to business people and illuminating engineers, of witnessing the different varieties of illumination and the many possible devices that can be applied to window-lighting. The display was rendered specially valuable by the ingenious arrangement of the exhibits. Eighteen exactly similarly built shop-windows, each equipped with plate glass in the usual way, were grouped round the four sides of a great square, so that the observer, standing inside the square, could examine several windows at the same time, and critically compare the illuminating effects with one another. Each window was equipped with tastefully displayed wares exactly as would be the case in the street; and the firms exhibiting were able to select different sources of light and different arrangements of wares in the windows in order to show their methods to the best advantage. The whole display was specially interesting to illuminating engineers for the reason that examples of exceedingly tasteful and effective methods of lighting were ranged side by side with others which demonstrated most emphatically how a display window ought *not* to be illuminated.

Let us next consider the purposes which the illumination of display windows can really be said to serve. A show window is one of the best methods of display for any business man—if not the best. Any other method of advertising, whether by placards, illuminated signs, or any other device, is only suitable for the purpose of drawing attention to his goods. A display window, on the other hand, shows these goods to the passer-by, as they actually are, in all their attractive elegance; it both attracts attention and stimulates the desire to buy. In the daytime this is effected solely by tasteful methods of decoration and display; but in the evening the salesman can derive powerful assistance from the possibility of controlling and arranging the illumination of his window so as to be specially adapted to the effect he wishes to produce. Not every striking method of illumination can be said to be effective, and just in the same way effective illumination is not necessarily striking; in the happy combination of both these intentions lies the great art of window illumination.

If two shops flood their wares with light in an extravagant manner, the shop between them appears by contrast to represent moderate but yet striking illumination, while, of course, the converse is equally true. Yet one must always take account of the prevailing taste in these matters, which

at the present time finds expression less in the adoption of any striking system, but rather in adequate illumination in sympathy with the wares it is intended to display.

At the present time six distinct methods of window illumination can be distinguished, as follows :—

1. Row-illumination. 2. Ceiling-illumination. 3. Side-illumination. 4. Exterior-illumination.. 5. Illumination by means of diffused lighting; and, finally, 6, mixed illumination, in which several methods of illumination can be employed in order to produce a given effect.

Row-illumination consists essentially in the placing of a row of sources situated at a given height above the ground, as, for instance, gas-jets placed along a gas pipe or glow lamps mounted at regular intervals. This method is not a satisfactory one, and cannot easily lead to really tasteful illumination. It is chiefly used in small concerns and shops.

Very pleasing effects can be achieved by means of *ceiling-illumination.* In this method the lamps are either mounted on the ceiling or are partially let into it.

Side-illumination is of special value in the cases in which a general effect is to be produced. Any danger of dazzling the eyes of the onlooker can be avoided by hiding the individual lamps in suitable reflectors, so that no direct rays pass out through the window. For the display of carpets, drapery materials, furniture, and so on, this method is very effective.

By placing lamps outside the shop very serviceable illumination can be obtained if the sources are correctly arranged, but as a rule these lamps are so carelessly hung that the observer is either dazzled by the direct rays from them or by the reflection of their illuminated surface in the plate glass windows or other shining surfaces in the window. The public illumination of streets and open spaces, and especially the illumination of display windows by means of unshaded lamps, has become an actual nuisance. In most large towns one can scarcely take a step without encountering cases in which dazzling of the eyes takes place.

Diffused lighting presents a sharp contrast to these external methods of illumination. By the latter method the light streams from the outside into the window, so that passers-by are chiefly attracted by the amount of light displayed in the window and thrown upon the wares contained therein.

In the case of diffused illumination, on the other hand, the lamps are arranged high above the window behind a frosted or opalescent glass roof. By this method the rays are diffusely distributed, and the contents of the window and the pavement are flooded with a bright and uniform illumination. All danger of dazzling is avoided, yet the smallest object is perfectly visible; both to the salesman and the customer this method of illumination, which produces an excellent impression, is very convenient. Indeed, it may be said that there is no modern system of illumination so well adapted to window-lighting as these diffusing methods. They are applicable to almost all conditions, but are especially effective in the case of sweet shops, linen draperies, jewellers, shops devoted to needlework and the like.

In *mixed-illumination* a combination of several of the previous methods of illumination are employed. In this way quite startling effects can sometimes be produced, especially when it is desired to bring into prominence special objects within the window. It is also possible to illuminate furniture, &c., in a tasteful manner that can hardly be arrived at by any other method.

Let us now consider critically some of the actual exhibits detailed for the purpose of comparison; we may divide these into excellent, good, moderate, and bad.

Excellent effects were produced by some methods of purely diffused arc lamp illumination, to which, in one instance, an ingenious colour change arrangement was added, so that the shop could be flooded at intervals with a mild white, red, yellow, or blue light. Yet one may entertain some doubt

as to the value of this method in the case of linen-drapers and other shops where coloured goods are displayed. Other excellent systems of illumination were effected by ceiling-illumination with Nernst lamps, side-illumination with Tantalum lamps, Just-Wolfrom lamps, &c. In all these cases bright illumination was obtained, and yet any danger of dazzling the eye was avoided by the careful use of frosted shades or reflectors. Window illumination that might be described as "good" was obtained in several cases by the use of enclosed arc lamps. In one case two lamps were hung close to the ceiling inside the show window, while two others were employed for exterior lighting. Here, however, the dazzling of the eyes was not entirely avoided, although the effect was not very serious, partly because the lamps were hung fairly high up, and partly because of the comparatively small surface brightness of the globes. It was surely not without an object that this method was applied to gentlemen's clothing and linen. In other cases, where objects presenting very extended and stationary surfaces were to be illuminated, the use of the somewhat unsteady light from enclosed arc lamps might prove unsatisfactory.

Those windows which were illuminated with inverted incandescent mantles might also have been ranked not only as good, but as excellent examples of window illumination, had it not been that the inconvenient arrangement of the lamps outside the window were apt to dazzle the observer, either through his receiving the direct rays from the source itself, or of the bright image of it by reflection from the show window. Moreover, in these cases, adequate—and therefore effective—illumination might well have been obtained without the use of any outside lamps at all. Again, in one exhibit, where excellent diffused interior illumination was employed, exterior flame-arc lamps, having insufficiently large globes, and provided with no screen in the direction of the pavement, were added. So marked is the dazzling produced in such cases, that this method of window-lighting constitutes, as previously remarked, an actual nuisance, and it cannot be sufficiently condemned.

The utilization of miniature arc lamps for the illumination of a richly decorated table must also be ranked as only moderately good, because in this case a very steady source of light is desirable. This defect was emphasized by the streakiness of the globes employed, which caused light and dark patches to appear upon the table-cloth.

As an example of what an illuminated window ought not to be we may mention several cases in which unshaded incandescent mantles were used, and no attempt was made to screen the eye of the observer; the naked and intensely brilliant mantle was allowed to play direct upon the eye. In another case, a lamp of this kind had, indeed, been equipped with a diffusing surface on the street side of the lamp, but the unshaded incandescent mantle, only slightly reduced in brilliance, could be seen by reflection in the shop window. In general far too little attention is paid to the possibility of directly dazzling the observer in this way; the image of the source of light thus seen by reflection from the window is almost as trying to the eye as the source of light itself.

There were also several other illuminated windows which likewise exemplified some pitfalls which must be avoided in lighting with glow-lamps. For instance, the shop was, in one case, illuminated with metallic filament lamps, but only about half of each lamp was obscured by means of a holophane shade, so that the eye could easily perceive and suffer from the exceeding great intrinsic brilliancy of the naked filament. The same thing might be said with even greater force of the exhibit of metallic filament lamps by another firm, in which only the lower half of each lamp was frosted over. In this case the lamps were enclosed in small lanterns, the sides of which were made up of clear glass, the upper portion consisting of a silver glass surface. Different opinions might be formed as to the merits of this arrangement according to individual taste, but probably few people would

have considered it a really artistic method of decoration.

The first portion of the inquiry, "How can a modern display-window be illuminated in the most effective and cheapest way"? may therefore be solved in a variety of ways. But which is also the cheapest method of illumination? In almost every case the illuminated window was provided with a placard giving complete details of the cost of installation, the cost of energy taken by lamps, and the cost of renewals per 1,000 hours, so that those present were able to make a note of the probable relative costs of the different systems.

Though this was extremely convenient for those interested in the matter, it may fairly be said that the question of cost does not enter very materially into the problem of really effective display-window lighting. The far-sighted salesman will not shrink from the naturally increased cost of a really effective advertisement in comparison with one of lesser merit. *In short, the most effective system of display-window lighting is at the same time the cheapest.*

It is naturally not aways easy for the merchant to weigh the merits of all the many methods of illumination and varieties of illuminants at his service, and decide which are best adapted for the illumination of his special display of goods. Moreover, it is often desirable to be able to alter the kind of illumination of a window at will so as to continually produce new and charming effects of light, and rivet the attention of the passer-by. This intention calls for the services of a capable illuminating engineer, and can be satisfactorily met in most cases by arranging for the simultaneous provision of several alternative methods of illumination. For instance, we may design the installation in such a way that either diffusing arc lamp illumination, or ceiling-illumination by means of glow-lamps, or side-illumination, can be used as desired. The method of illumination giving rise to the most effective results in special circumstances can thus be secured at will. Of course, this necessity is mainly experienced by large establishments, in which not one variety of goods only is shown, but many different varieties, such as furniture, confectionery, gentlemen's clothing and linen, &c.

Finally, we may lay down the following rules, which may be said to form the basis for effective shop-illumination :—

1. The window must always be so illuminated that even the smallest object is clearly distinguishable.

2. The attention of the passer-by is attracted not merely by an extravagant and dazzling expenditure of light, but by the effectiveness of the illumination.

3. The more original and striking the form of illumination employed, the greater its ability to attract attention.

4. The choice of the varieties of illuminants and methods of illumination adopted must be determined by the nature of the goods to be exhibited.

Shop-Window Lighting.

In commenting upon the March number of *The Illuminating Engineer, The Builder* remarks :—

"The current issue has a special section on 'Illumination and the Architect,' in which a plea is advanced for greater co-operation between the architect and the illuminating engineer. The journal contains several articles of interest to photometrists. We hope the influence of this periodical will be used to put a stop to the display of batteries of powerful arc lamps outside shop-windows. The Corporation of London introduced a short time ago a regulation prohibiting the use of unshaded high power lamps outside shops in City streets, but they appear to lack either the power or the courage to enforce the regulation, for some of the most dreadful examples of vulgar and garish shop-lighting are still allowed to dazzle and annoy City pedestrians."

The Economical Illumination of Display Windows.

By J. D. Mackenzie.

(*Continued from p.* 119.)

The following table gives watts expended and candle-power per cubic foot of window space, which may serve as a basis for further comparison.

From the foregoing table it will be noticed that the nominal candle-power per cubic foot of window spaces varies from 1·53 to 2·42, excluding the effect of the outside lamps, and it may safely be assumed that for modern requirements in well-lighted streets 2 candle-power per cubic foot of window space is practically essential. Consequently this figure may be used to give an approximate pre-determination of the light required in any given case. When outside lamps are in use the interior candle-power may be considerably reduced, especially if the exterior lamps are fitted with reflectors arranged to throw a proportion of the light toward the windows.

In some lines of business, where goods are dressed close up to glass, or where they are of such a nature as to reflect most of the light falling on them, it is possible to obtain a thoroughly satisfactory illumination without any interior window lights. For this purpose electric or gas arc lamps are absolutely essential (except in the case of the very smallest class of windows where clusters of the metallic filament lamps may advantageously be employed), if the most economical results are desired, and special care is required in placing lamps so as to obtain the best effect. A knowledge of the polar curve of the particular lamp installed is of use in determining the best position. Besides this, however, careful consideration should be given to the consumption of the individual lamps and a judicious use made of the smaller types wherever possible. Reflectors should also be fitted to direct the light in the required direction. Of course, as previously indicated, the lighting of the thoroughfare has a good deal of influence on the size of lamps necessary.

Perhaps one of the most difficult classes of window to light is that of a clothing warehouse. Generally speaking the windows are large, the goods comparatively dark, and the only way in which the lighting effect may be enhanced is by a liberal use of mirrors. This, however, is not always possible, and even when possible is not always advisable. To fit up the back or inner side of the window with mirrors would undoubtedly greatly assist in reducing the expenditure of energy required in lighting the window, but against that must be placed the fact that so doing renders the interior of the shop dark, making it necessary to use artificial lighting inside the shop all day long. Such a method does not tend towards economy in illumination, and hence a balance should be struck between the window lighting and the interior lighting of the shop.

From an analysis of various shops of this nature the writer finds that the expenditure of energy required to give a satisfactory illumination varies from 1·5 watts per cubic foot of window space (using enclosed arc lamps with white enamelled reflectors) to 3 watts per cubic foot, using open type arc lamps without reflectors. Flame arc lamps, except those giving a white light, are unsuitable for this class of work.

In concluding this short article the writer must deplore the fact that there is so very little reliable data to be had regarding the illumination necessary for various purposes, and hopes that

the interest now being taken in the subject will result in the accumulation of information from which reliable data could be obtained. During the last year or two a great improvement has taken place in shop window lighting, particularly in the matter of concealing the lamps and yet obtaining the lighting effect, but a great deal remains yet to be done. In the meantime the illuminating engineer can only form his opinions more by intuition than by scientific data.

Errata :—TABLE I.

Tobacconists A and A_1	Watts	Burning cost per hour.	Relative Costs for Equivalent Light.
Instead of	300	1·050*d.*	4·991
Read	400	1·400*d.*	7·347

TABLE II.

Shop.	Cubic feet of window space.	Watts, or cubic feet of gas.	Nominal candle-power.	Watts per cubic foot.	C.P. per cubic foot.
Hatter and Hosier ...	112 cubic feet	240 watts (without arcs)	172	2·14 watts	1·53
,, ,,	112 ,,	990 watts (with arcs)	972	*5·5 ,,	*5·1
Jeweller ...	71 ,,	330 watts	172	4·65 ,,	2·42
Tobacconist...	71 ,,	160 watts (without 100 c.p. outside Osrams)	120	2·25 ,,	1·7
,,	71 ,,	400 watts (with 100 c.p. outside Osrams)	320	*4·0 ,,	*3·0
Stationer ...	160 ,,	21 cubic feet gas per hour	†370	0·13 cu. ft.	2·3
Confectioner...	160 ,,	17·5 cubic feet gas per hour.	†310	0·11 ,,	1·94

* In these cases the consumption of one outside lamp only is debited against the window, the other lamp being in each case used to light up the doorway; similarly, the C.P. of only one lamp is taken into account in the "C.P. per cubic foot" column.

† Candle-power reckoned on the basis of approximately 18 c.p. per cubic foot of gas.

Artificial Illumination, Historical and Practical.

THE above formed the title of an interesting lecture by Mr. A. E. Battle before the Institute of Marine Engineers on March 9th.

Mr. Battle traced the evolution of lighting from the days of the camp-fire, the torch, and the very earliest forms of oil-lamps, up to the newest forms of electric glow-lamps and the incandescent mantles of the present time. At this point the subject was taken up by Mr. Holmes, of the West Ham Electrical Supply, who briefly dealt with the development of metallic filament and the newer arc lamps and their relation to the consumer and the electric lighting industry. His remarks were illustrated by an exhibition of tantalum, Osram, flame-arc, and enclosed arc lamps, and also various electrical heating devices.

A brisk discussion followed, in which a keen interest in the subject of illumination was displayed, Mr. Holmes being called upon to reply to many questions dealing with the value of the newer forms of illuminants to the consumer.

The Production and Utilization of Light.

A Brief History of Artificial Lighting.

By Dr. C. V. Drysdale.

(*Continued from p.* 200.)

Glow Lamps.—The earliest attempts at practical electric lighting by incandescence were made by employing a bad contact between carbon pencils and discs. De Moleyns of Cheltenham in 1845 produced the first lamp of this kind, and Varley in 1876 and Reynier in 1877 produced lamps in which a fine carbon pencil made contact with a rotating carbon disc. The incandescence in this case was accompanied by combustion. Werdermann and Joel employed the same principle.

In 1841, however, the first purely incandescent lamp was produced by De Moleyns using platinum wire. Iridium and its alloys were used by Petrie in 1849. In 1845 a patent was taken out by King (probably acting for Starr, of Cincinnati), for a carbon filament in an exhausted bulb and an electrolier of electric lamps was shown by Starr and Faraday. In Starr's lamp the carbon was probably in the form of a pencil or slip of gas retort carbon, which being fairly solid could be rendered incandescent in a comparatively poor vacuum without rapidly burning away. It seems, however, that by the same year Mr. (now Sir Joseph) Swan had succeeded in producing thin carbon filaments by employing paper or thin card and slowly carbonizing it in a pottery furnace, the process of carbonization almost identical with that now employed. These filaments being much thinner required a higher vacuum, and it was not until the introduction of the Sprengel Pump into this country about 1875 that a durable lamp could be produced. Heinrich Göbel, of New York, appears to have produced a carbon filament lamp in 1854, first using wood charcoal and afterwards carbonized bamboo. But these early inventions seem to have been lost sight of, and the subject appears to have been revived by the physicist Lodyguine in 1873, who wrote an essay pointing out the importance of high specific resistance and high melting point in materials for the filament, and that carbon best fulfilled these conditions. Edison, after experimenting with platinum spirals, commenced in 1877 to attempt the production of carbon threads. He also realized the importance of high resistance, and engaged a mathematician, a former student of Helmholtz, who came to the conclusion that the filament must have a resistance of at least a hundred ohms to permit economy in the leads.

In 1879 a lamp was made with a horseshoe carbon filament 5 to 6 cm. long, of carbonized brown paper, in a bulb exhausted to $\frac{1}{100.000}$th atmosphere, and in 1880 he employed carbonized bamboo. In May, 1880, a lighting installation was arranged on the steamship "Columbia"; and at the Paris exhibition in 1881, 1,000 glow lamps were shown running from a large Edison dynamo. In the same year Swan produced filaments by parchmentizing cotton in a mixture of one part sulphuric acid to two of water, which gave more uniform filaments.

Lane Fox employed the process of flashing the filaments originally suggested by Sawyer, thus further improving the uniformity of the filaments. Since then the squirting process of producing filaments from a solution of cellulose in zinc chloride was introduced by Swan, and the flashing process of mounting the filaments. Great improvements have been made in constructive processes by Weston, Swinburne, and many others; while recently a considerable advance has been made by the General Electric Co. of America in the graphitized or metallicized carbon filament, prepared by

subjecting an ordinary filament to the heat of the electric arc. By this means the efficiency of the carbon lamp has been increased to 2 or 2½ watts per candle.

Metallic Filament Lamps.—Most of the pioneers of incandescent electric lighting endeavoured to employ metallic wires. Davy in 1810 brilliantly incandesced a platinum wire $\frac{1}{30}$th inch thick and 18 inches long; and unsuccessful attempts were made by nearly all the early workers to make platinum filament lamps, the difficulties lying in the low melting point and the low specific resistance of platinum. Edison, indeed, noticed later that when platinum was heated and cooled repeatedly, driving off all occluded gases, it became much harder, and could then be raised to seven or eight times the ordinary safe degree of incandescence. Iridium was suggested by Petrie and tried by Staite, Starr, Molt, Edison, and others; and De Lodyguine, besides giving attention to carbon filaments, experimented in the United States from 1892 to 1894 with filaments of molybdenum, tungsten, rhodium, iridium, ruthenium, osmium, chromium, &c., depositing these metals upon a carbon core or "fillet." The first commercial metallic filament lamp was that of Osmium devised by Dr. Auer von Welsbach, and this has been succeeded by the tantalum lamp of Bolton and Siemens, and the many various forms of tungsten lamps in which the filaments are prepared by the different processes of Just and Hanaman, Kuzel, and others. Zirconium, titanium, and selicon carbon have also been employed, and at the present time almost every month sees some new form of lamp, having efficiencies of about 1 watt per candle, and gradually increasing voltages from the 25 volts of the early Osmium lamps to the 200-240 volts of the zircon wolfram and other lamps at present.

Non-Conducting Filaments.—As far back as 1877 Jablochkoff observed that several non-conducting substances, such as kaolin and magnesia, became conductors when hot, and succeeded in maintaining a kaolin strip incandescent by an electric current. Although this was experimented with by others, it was left for Dr. Walther Nernst in 1897, working under the auspices of von Welsbach, to produce a commercial lamp, using filaments of the rare earths used in the Welsbach mantles, such as Thoria, Yttria, &c. Many difficulties had to be surmounted, notably those of automatic lighting, and of overcoming the high negative temperature co-efficient, which led to unstability and increase of current to the breaking point, but these were successfully overcome by the use of a heating coil and relay, and by "bolstering" resistances having a large positive temperature co-efficient. The Nernst lamp so made gave a light of from 1·5 to 2 watts per candle efficiency, and has been found very satisfactory on high voltage circuits.

Vacuum Tube Lamps.—The light produced by passing a high potential discharge through gas at low pressure was employed in France for a miner's lamp, using an ordinary Ruhmkorff coil. Recently, however, it has been developed on the large scale by McFarlane Moore, using tubes about 1¾ in. diameter and up to 200 ft. long, with a high voltage transformer and using a special valve to admit a small quantity of air at intervals. This light is fairly efficient and well diffused, as well as being of pleasant colour if nitrogen or carbon dioxide is used, and will probably come into considerable use.

Luminescence.—In 1879 Sir Wm. Crookes found that when a tube was very highly exhausted streams of what he termed radiant matter were discharged from the negative pole or cathode, and that the surface of the glass where these rays impinged glowed with a green light. Other solid substances also gave off light of characteristic colours. The term luminescence was given to this phenomenon by E. Wiedemann, and several investigators have given attention to it. No commercial form of luminescent lamp has yet been devised, but it is generally recognized that the method has great possibilities, and special mention will be made of it later.

(*To be continued.*)

The Development of the Electrical Metal Filament Glow-Lamp.

By Dr. H. Weber.

There is one point in connexion with the history of incandescent glow-lamps which must strike every one as somewhat remarkable, namely, the fact that attention was paid to the use of metals for the very earliest filaments, that subsequently these filaments were abandoned in favour of those made of carbon, but that at last it has been found desirable to come back to metallic filaments again. One is inclined to wonder how it could be possible that the excellent qualities of the metals used in the filaments of the most recently developed electrical lamps were not recognized earlier, and that so great a lapse of time followed before any practical results with these metals were obtained.

We must, however, remember that previous to the years 1868 to 1875, when the first really practical incandescent lamps were produced, the properties of the materials employed therein were not so well known as they are to-day, and that, in addition, we had not at our disposal the same well-developed processes of manufacture that are now common. Whenever any investigation proved abortive it was always concluded that the material employed was of no value, and the fact was not recognized that it was very often only the method of manufacture of the glow-lamp filament which was unsatisfactory. How otherwise could it have been possible for the, to-day, so generally used metal tungsten to have remained unnoticed, after being made use of in the year 1889 by Lodiguine and Tibbits, though certainly without any practical result?

Tibbits soaked cotton and silk threads in a solution of tunstic acid, and subsequently rendered the threads incandescent in an atmosphere of hydrogen, the temperature being 1,800 degrees Centigrade. By this process tunstic acid was reduced, and the tungsten separated out on the surface and interior of the threads as a hard shining metallic deposit; filaments so prepared were mounted in lamps by Tibbits, but proved to be of no practical value; but, had the inventor possessed the knowledge of the physical and chemical properties of the metal that are to-day at the service of the glow-lamp industry, he would have known that the reason of this failure lay in the now fully recognized fact that the tungsten is unserviceable if it contains appreciable quantities of carbon, either free or in a combined form. By the aid of our present knowledge and better methods of manufacture it might, perhaps, have been possible to have produced a 1 watt per candle-power lamp by the year 1889, though such a lamp was actually publicly exhibited for the first time in the year 1906. The author now proposes to outline the principles underlying the most recent developments of metallic filament lamps, though it will naturally be advisable to refer occasionally to carbon lamps in so doing.

The glow-lamps of the present day may be said to have arisen from the original discovery that a fine metal wire can be brought to incandescence so as to give out light by the passage of a suitable current. The first metallic filament lamp may be said to have been devised in the year 1802, when Humphrey Davy succeeded in bringing a fine platinum wire to incandescence. For a long time after nothing further occurred as a result of these experiments, but in 1841 F. Moleyns, of Cheltenham, took out a patent having for its object the improvement in the output of light of the filament by a deposit of fine carbon on a suitable metallic wire, preferably platinum. In the year 1845 Starr & Grove exhibited an exhausted incandescent lamp,

which consisted essentially of a platinum wire of suitable resistance, into which a current was led by means of thick copper strips. By the use of a suitable battery Grove was able to produce a serviceable light lasting several hours. Subsequently, in 1847, J. W. Draper, of New York, described some investigations in Stillman's *Journal* (second series), in the course of which platinum wires were heated in an electrical current, while Petrie, in 1849, proposed to employ the refractory metal iridium in the place of platinum. (This very metal iridium has been recently employed for low-voltage lamps by Gülcher.)

Yet all these researches led to little practical result, and this can be readily understood at the present day, for just those metals were employed which are least well adapted to serve as an incandescent filament. Even Edison, who is often incorrectly regarded as the actual inventor of the carbon filament lamp, had some difficulty in freeing himself from the supposition that platinum would make good filament, and, in the year 1880, actually took out a patent, according to which 30 ft. of platinum wire, 0·005 inches in diameter, were wound upon a cylinder of lime and brought to incandescence. Although by this arrangement the fairly high resistance of about 750 ohms was obtained, the lamp did not find any practical application. Yet Edison himself seems to have been so firmly convinced of the results of this discovery, that he had some fear lest the entire output of platinum of the world might not suffice for the desired number of lamps. This led to the humorous picture of Edison sending out a small army of prospectors and chemists into the world in order to search out new sources of platinum.

However, soon afterwards Edison seems to have realized that satisfactory filaments could only be composed of materials having a high resistance, such as carbon, and from this date onwards efforts were made to construct, incandescent filaments out of pure carbon, and to produce these filaments in the necessary homogeneous and elastic state. Space does not allow the author to deal with these attempts in detail, and readers who desire further details are referred to his recently published book on the subject ('Die Kohlenglühfäden für elektrische Glählampen').

It need only be mentioned that when the efforts to make serviceable carbon filaments had proved successful, it was still necessary to construct filaments capable of standing a higher temperature in order to secure the higher output of light. In order to attain this object carbon filaments were first impregnated with metallic solution, or by other methods coated with a fine surface of metal or metallic mixtures. These experiments, however, all led to but little result, for the simple reason previously mentioned, that so long as carbon is present in any considerable quantity in such a filament, it becomes impossible to increase the efficiency of the lamp very greatly without the bulb soon showing signs of blackening. It seemed, therefore, impossible to secure any great gain in efficiency so long as carbon was employed. Attempts were subsequently made to employ other materials such as boron and silicon, &c., until eventually the pure metals were employed once again.

It is interesting to observe that just as platinum was originally very universally employed, so the metal osmium formed the basis of the first practical result in the metallic lamp industry, and for many years formed the single example of a serviceable metallic lamp. Auer von Welsbach was attracted to the use of the osmium by the fact that it is the most refractory metal of the platinum group, having a melting point near 2,600 degrees Centigrade, and succeeded in producing lamps which could be run at an efficiency of 1·5 to 1·6 watts per candle-power. Osmium consists of a grey-black powder with a specific gravity of 22·48, and is prepared from osmiridium. This metal, one of the heaviest of this group, was at first deposited upon fine metallic wires composed of some substance having a low melting point; this, easily melted metal was then vapourized by heating the filament

to incandescence by the passage of an electric current, leaving the osmium behind.

But the osmium filaments obtained in this way proved to possess very inferior qualities, and their great brittleness proved very inconvenient in the manufacture. Subsequently the metal was reduced into a fine powder, mixed with a certain oxide of osmium, and worked into a soft paste with sugar solution, the paste being forced under high pressure through diamond apertures. These filaments were next dried and were "formed," that is to say, converted into a metallic state, by heating with an electric current in a certain gaseous atmosphere. The oxygen accompanying the metallic osmium combined with the carbonaceous material of the sugar, the oxide was completely reduced, and filaments of pure metallic osmium resulted.

The filaments prepared in this way were, however, still extremely brittle, and could only be produced of a certain diameter, with the result that it was found impossible to produce lamps for pressures higher than about 73 volts. Further difficulties in their manufacture lay in the fact that the rare metal osmium naturally exists in certain limited quantities, so that the Auer Company were put to some difficulties to obtain a sufficient quantity. For this reason lamps were not sold outright, but only loaned, so that the company might utilize the osmium in the used-up lamps, *de novo*. Finally, it should be mentioned that the lamps could only be burned in a vertical hanging position on account of the softening of the incandescent filament, which might otherwise lead to a short circuit, and so destroy the lamp. The lamps, however, proved very successful, for they could be burned at an expenditure of 1·6 watts per candle, with a life of about 800 to 900 burning-hours.

It only remained to discover other materials which did not possess the drawbacks of osmium—brittleness and high conductibility. After many failures the firm of Siemens and Halske succeeded in manufacturing a lamp with a filament of the rare metal tantalum, derived from the compound $Ta_2 O_5$. This occurs in the minerals tantalite and columbite which are obtained from Grönland, North Carolina, Sweden, &c.; these minerals generally contain not only tantalum, but also compounds of the very similar metal niobium, which accentuates the weak points in the metal tantalum. It was thus necessary to devise a chemical method for the separation of the two metals, and this was achieved by utilizing the tantalum-potassium and niobium-potassium fluorides. The pure tantalic acid so obtained was reduced to the metallic form by means of sodium or potassium. The metal prepared in this way is a black powder, and was formed into a paste containing a suitable binding material, which was pressed into rods, and heated by means of an electrical current in vacuo. As a result the particles of tantalum sintered together into shining metallic strips, which were, however, too thick to be of any practical use. As the author for several years acted as assistant to Dr. von Bolton, the inventor of the tantalum lamp, and has had the opportunity of watching its development from the earliest beginnings, he is in a position to give some details which may be of interest as to the development of this lamp.

It was found desirable to melt together a considerable quantity of pure tantalum for the purpose of certain experiments. For this purpose the thick rods previously mentioned were heated by the passage of an electrical current in a vacuum until the metal was brought into a molten condition. During the experiment the metal mass broke and separated, with the result that an arc was created between the two portions, and small molten globules of the metal were formed. These globules were subsequently examined more closely, and hammered on the anvil with a view to testing their hardness, when the ductibility of the metal was accidentally discovered, and the method of manufacturing glow-lamp filaments by simply drawing out wire tantalum suggested. For the purpose of further experiments on the metal in this state a thick rod was allowed to break up while heated by

the electrical current in the method described, and molten globules of the metal obtained. These globules were pressed out into very fine sheets, strips were cut out of the sheets and mounted, and the first tantalum lamp, which had a life of 70 to 80 burning-hours and ran at a pressure of 10 volts, was produced.

It was subsequently found that the ductibility could be very considerably improved if the metal was prepared absolutely free from impurities, especially traces of oxygen and hydrogen. In order to attain this result the metal is heated several times in vacuo, the arc formed as before, and a metallic regulus obtained which could be drawn out into wires as fine as 0·03 mm. in diameter. From wire of this description lamps yielding 50 candle-power can be obtained for a supply pressure as high as 220 volts. Unfortunately, however, the tantalum lamp cannot be said to have quite fulfilled the expectations aroused by its arrival, for, apart from the successful production of sufficiently strong filaments, capable of standing transport without breakage, and suitable for use on 200 volt circuits, there still remains the drawback that the lamps can only be prepared with difficulty in a form suitable for use with an alternating current, and that the mean consumption of power is on the average not less than 1·8 watts per H.K. A type has recently been put on the market in which the consumption is 2·3 watts per H.K. One would suppose, however, that even the 1·8 watts per H.K. lamp hardly satisfied present requirements, for it was found necessary to counteract this comparatively high consumption per candle-power by a corresponding reduction in the price of the lamp. Actually the tantalum lamp of to-day amounts to one-third of the earlier price, and may be said to be richly rewarded thereby, for it does not appear to possess any very great advantage over the new metallized carbon lamps having a consumption of 2·5 watts per H.K.

More recently the attention of the glow-lamp industry has been turned to an entirely different group of metals which, however, were known a long time ago, namely, tungsten, molybdenum, &c. As was mentioned before, it may seem peculiar that the wonderful properties of the members of the chromium group of metals should now be realized for the first time, in spite of the fact that the metals in question were discovered and studied as early as 1783 and 1797 by Klaproth and the Brothers d'Eljuhar. It was explained above that the application of tungsten to glow-lamp filaments was tested nineteen years ago, and that the experiments of Lodiguine and Tibbits at that date led to no result.

The processes of manufacture of the new filaments differ very greatly, and can only be described very briefly here. The majority of them involve the reduction of the metal into a finely powdered form, the subsequent mixture with some binding material into a pasty mass, and the forcing of this paste through fine dies into filaments. The chief detail to which attention must be paid is the absolute necessity for the resulting filament being entirely free from carbonaceous constituents. In the so-called "paste-process" a metal containing an acid constituent is employed mixed with an organic paste, which becomes carbonized when heated. The materials are intimately mixed together, and forced through fine diamond dies. The resulting filaments are dried, and eventually brought to a high temperature in vacuo, in order to render them conductive. During this process the organic paste becomes carbonized, and eventually combines with the acid constituent to form carbonic acid. Thus the filament is completely freed from the carbonaceous material and the injurious acid constituent, and should now consist of pure metal.

Naturally, however, this chemical reaction does not follow its exact theoretical course, and small traces of carbonaceous material generally remain in the filament. In order to remove these traces completely additional processes are commonly employed.

For instance, the Auer Co. secure a complete removal of the carbon by treating the filament in an atmosphere

of hydrogen. As the results were not entirely satisfactory this method was soon modified. The vessel in which the treatment of the filament took place was completely evacuated, washed out several times with pure dry hydrogen, and eventually filled with a certain quantity of pure, dry, acid-free nitrogen. When the filament was heated to a high temperature in this atmosphere the carbon was completely removed by the combination of the carbonaceous material with the nitrogen to form cyanogen. As regards the name "osram" it may be remarked that this word is a combination of osmium and wolfram (another name for tungsten); as a matter of fact, however, the filament does not contain a mixture of osmium and wolfram, as is frequently erroneously supposed, but only pure wolfram.

Another process by which tungsten metallic filaments are obtained absolutely free from carbon is that devised by Dr. Kuzel of Vienna, who, by a special chemical process, converts the metal into a gelatinous or "colloidal" condition, such that it can be easily pressed out into filaments. The filaments are then dried and sintered together in a high vacuum The method is such that no further treatment is needed to remove carbonaceous impurities. Yet another method adopted by the General Electrical Co. in Austria-Hungary is as follows: perfectly pure tungstic acid is mixed with a binding material, forced into filaments, and the filaments brought to a temperature of 600 to 700 degrees Centigrade in a stream of hydrogen. By this means tungstic acid is reduced to metallic tungsten, and a metal filament results, which contains but slight traces of carbon; in order to remove these traces either of the special treatments previously mentioned may be used.

An entirely different method of constructing tungsten filaments is that by which filaments of carbon or some other metal are heated in an atmosphere of tungsten chlorides and hydrogen, with the result that the deposit of tungsten gradually permeates the carbon or metal throughout.

Finally, there have been unsuccessful efforts to draw tungsten into wire, in the same way as tantalum. By one such method tungsten is mixed with some easily volatalized metals, drawn into wire, and then the foreign metals expelled in vacuo. Unfortunately filaments so produced are too fragile to be of any practical value.

On the whole, it may be said that of all these methods the first-mentioned paste method, after the removal of certain difficulties, has yielded excellent results; at first it was not possible to attain a strong and completely uniform filament; yet we have eventually learnt to manufacture even the finest varieties successfully. When one bears in mind that such filaments are actually composed of isolated metallic particles built together, one cannot but wonder at the elasticity which even the finest of them exhibits. It is already possible to manufacture filaments in large quantities, having an ultimate diameter of only 0·03 mm. These can be utilized in lamps giving 18 H.K. at 100 volts or 36 H.K. with 220 volts, which is certainly an excellent result. In this connexion it may be mentioned that the entire length of the filament of a single lamp intended for 110 volts and yielding 18 H.K. is as much as 42 centimetres long.

In conclusion it may be remarked that the actual mounting of filaments in lamps at first presented very great difficulties.

For instance, difficulty was experienced in designing the lamps to burn in any position. In order to render this possible small light supports are provided, which take up the shortening and lengthening of the filament in its hot and cold state. When the lamp is switched off and the filament becomes cold, this support gives way with the shortening of the filament, so that the latter is not subjected to a strain, and does not tear away or break. These lamps can also be burned in a horizontal position, for the support possesses sufficient strength to keep the glowing and pliable filaments stretched, and prevent them sinking downwards.

The Relative Hygienic Values of Gas and Electric Lighting.

By Dr. Samuel Rideal.

(A more detailed account of the researches of Dr. Rideal described in this article will be found in the Journal of the Royal Sanitary Institute for March of the present year, vol. xxix., No. 2.)

Object of Investigation.—The purpose of this inquiry has been to determine and compare the hygienic effects of gas and electricity as used for ordinary domestic lighting.

Three parallel lines of research were indicated as desirable, firstly, into the direct hygienic effect of the two lights; secondly, into the indirect effects of their products; and, thirdly, into the nature, amount, and distribution of these products. The three lines of research were conducted simultaneously.

The investigation being essentially a medical one, priority was given to the physiological work; the chemical and physical part mainly consisted in arranging and recording the conditions under which the medical observations were made.

Rooms and Mode of Lighting.—The experiments were carried on in a room in the basement of No. 28, Victoria Street, which was, for the purpose of the second series of experiments, divided by a tight wooden partition into two chambers numbered 4 and 6, each having two windows with S.S.E. aspect, a fire-place and doorway, a wooden floor bedded on concrete, and brick walls 1 ft. 9 in. and 2 ft. thick.

Each room could be lighted from the centre with gas or electricity as desired. As far as possible the candle-power of each illuminant was made the same; but the photometric tests revealed the fact that the illumination of the table was greater with the inverted incandescent gas-burners, owing to the difference in the arrangement of the light-emitting surfaces.

As a rule the rooms were not heated, except by the lamps and the warmth derived from the inmates themselves; but during the latter part of January the weather became so cold that a non-luminous electric heater was installed, an open fire being inadmissible on account of the extra ventilating effect it would have produced.

Chemical and Physical Observations.—Estimations of the amount of carbonic acid produced by inmates in the room and burners were carried out every quarter of an hour. Similar observations of the amount of organic matter in the air were periodically carried out by testing with a solution of potassium permanganate.

The physical observations comprised a record of the temperature and humidity of the room by means of wet and dry bulb thermometers.

Changes produced in the Air of the Room by the Illuminating Agents.—These may be classified as follows :—

Gas.

1. Heating effects.
2. Drying effect due to heat, modified by water vapour produced.
3. Production of carbonic acid.
4. Sterilizing action.
5. Ventilating effect.

Electricity.

1. Heating effects.
2. Drying effect due to heat.
3. None.
4. Sterilizing action.
5. Ventilating effect.

The changes in the air of the room, brought about by the occupants themselves should also be taken into account. They include :—

1. Heating effect.
2. Addition of moisture.
3. Production of carbonic acid.
4. Vitiation of air by other respiratory products.

Heating effects.—Theoretically the gas lamp gives out more heat than an electric lamp in the same candle-power. In these experiments two 25 candle-power electric lamps were found to give about half the heat of two gas lamps of the same intensity. Actually, however, observations of the temperature in the room showed very similar results in the two cases, even when the rooms were vacant, while the presence of people in the rooms gave rise to an amount of heat in comparison with which that given out by illuminating agents was of minor importance.

The Production of Water Vapour.—Naturally no water vapour is produced by the electric lamp. The amount of gas consumed in each room is about 2½ cubic feet per hour; this gave rise to about a quarter of the hourly weight of water exhaled by the six inmates of the room.

The Production of Carbonic Acid.—With the amount of gas burned mentioned above, the ratio of carbonic acid produced by gas to that produced by the occupants in the room is about one to three; hence at least three-quarters of any injurious effect produced by carbonic acid must be ascribed to the latter.

This substance, however, is a normal constituent of air, and now recognized to be harmless, even in much larger quantities than could result from any reasonable consumption of gas. In an adequately lighted and unoccupied room an amount of carbonic acid greater than 11 parts per 1,000 could not well be obtained, while in these experiments 50 parts per 1,000 were exceeded without any bad physiological effects resulting.

Sterilizing Action.—The sterilizing action—the power to destroy germs in the atmosphere—of an illuminant arises chiefly through the organisms coming in contact with heated surfaces such as are presented by gas flames and the bulbs of glow-lamps, the effect of sulphur acids created by gas burners, and increased ventilation due to heated air from the illuminants. The sulphur acids, which have marked germicidal properties, are, however, partially "fixed" by the whitewash coating of the ceiling and walls of a room. In these experiments gas-lighting appeared to possess greater sterilizing properties than electric, as was shown by the number of organisms per cubic centimetre in the air, or in water deposited from the air on cool surfaces in the room. This is partially to be ascribed to the greater temperature of the heating surface in the case of gas and the larger volume of air operated on.

Vitiation of the Air by other Products.—It has been believed that the injurious influence of ill-ventilated rooms is due to certain volatile organic materials given off by the lungs. The presence of such products was tested by the action of potassium permanganate solution, but these experiments do not seem to have confirmed the injurious nature of such organic matter. It was, however, noticed that the air of the gas-lighted room was invariably purer by this test than that in the room lighted by electricity, presumably because of the partial destruction of this organic matter by the burning gas, and also by reason of the better ventilation in the case of the illuminant.

Effects of Ventilation.—The ordinary room is not a stagnant mass of air, but is constantly receiving influxes from without. In these experiments at least one-third of the air was found to be changed per hour; this result was confirmed by studying the rate of disappearance of a large quantity of carbon dioxide added to the atmosphere. The ventilation was examined at the beginning and end of the evening's work, and it appeared that the heated column of air from gas-burners had a marked effect on the ventilation of the room; the air rising from the electric lamps was also effective, but to a less extent.

Medical Observations.—As mentioned at the commencement of this article, the conditions imposed, namely, that the experiments should be carried out under as natural conditions as possible, prevent the possibility of any strictly conducted physiological investigations. Though in some cases conditions more extreme than those generally met with have been aimed at, they still lie within the limits of the human power

of accommodation, and therefore do not produce any marked deleterious effects.

A large mass of data has, however, been collected under the following heads :—

1. Frequency of pulse and its character.
2. Frequency of respiration.
3. Arterial blood pressures.
4. Richness of blood in coloured corpuscles.
5. Body temperature.
6. Body weight.
7. Mental fatigue.
8. Time reactions of mind and muscle.
9. Eye fatigues (differentiated).
10. Impressions on senses.
11. A special experiment on three subjects as to the poisonous effects of coal-gas when present in large quantities.

The rate of the pulse depends primarily upon the frequency of the heart's contraction, which is affected by a variety of outside causes, and respiration also serves the purpose of ridding the system of an excess of carbonic acid, moisture, and heat. Therefore, the study of the alterations in these two quantities often serves to indicate a change in the conditions of environment.

As a rule the pulse rate was found to be high at the beginning of the evening, but, under the uniform conditions maintained in the room, dropped gradually, the average final frequency being practically constant, and the same with both systems of illumination.

The average frequency of respiration decreased under both systems of lighting in a very similar manner, and it is significant that the increase in the number of inmates in the room was more effective in producing this decrease than varying the illuminant.

The progressive change in body temperature and loss of body weight during the evening also proved to be very much the same in the case of both illuminants, and an examination of the blood corpuscles also gave negative results.

No very appreciable difference in the physiological effects of the two illuminants could therefore be traced, and an endeavour was made to ascertain whether there was any difference in their effects upon mental conditions. The test of mental fitness applied consisted in setting a long addition sum, and noting the length of time required to execute the same and the number of errors made. In the case of both lights there was a gain in speed but a loss in accuracy. But this gain in speed is presumably due not to the light, but to the rest after the day's work, and was very nearly the same in the case of both methods of lighting. The subjects were also tested for alertness by measuring the interval between the hearing of a signal and the response thereto, this period being indicated on a revolving drum. Again, there was no perceptible difference between the result of gas and electricity. As regards action on the eyes, the sensitiveness of the eye to light appeared to be appreciably diminished during exposure to electric light, an effect not to be noticed in the case of gas.

On the whole, the results of these experiments show fairly conclusively that under ordinary conditions either light can be used without the least prejudicial influence on health.

Finally a test was devised to study the effect of leakage of gas into the room. Ordinary gas contains poisonous constituents, including carbon monoxide, and has been known to give rise to poisoning through inhalation. In the course of these experiments three individuals were placed in a room—the door, windows, and fireplace of the same being blocked in such a way as to prevent ingress of air. Yet, although an amount of gas equivalent to three times the ordinary consumption of the burners—as much, in fact, as could only occur through breakage or some accident—was allowed to pass into the room, the subjects experienced no ill effects during the four hours and twenty minutes they were in the gas-laden atmosphere. When we bear in mind how easily an ordinary leakage of gas is detected by the smell we can see how difficult it is for a condition of affairs to be set up which would be really prejudicial to health.

General Conclusions.—The results of this inquiry may be summed up as follows :—

1. Owing to the better ventilation obtained by gas the products of combustion are not found in the air in anything like the proportion which might be expected, the temperature and humidity in an occupied room being no greater than when the room is lit with electric light.

2. Carbonic acid has not the injurious effect which was formerly attributed to it; but considerable rises in the temperature and moisture content of a room, from whatever source, do have a prejudicial effect upon the well-being of the occupants. Even under adverse conditions of ventilation purposely created for this inquiry, neither the temperature nor percentages of moisture in the room reached a point at which any such effect could be detected by any of the recognized physiological tests.

3. It has been established that the products, viz., heat, carbonic acid, and moisture, which might modify the health of the occupants of a room, are derived from the inmates to a far greater extent than from the illuminant, and that a room of moderate size can be efficiently lighted by gas without sensibly affecting the amount of these three factors.

4. Whilst undoubtedly it is important to ensure adequate ventilation in domestic rooms, this, with present methods of construction, is ensured better the smaller the room. The problem of securing sufficient ventilation has only to be considered in public rooms of a larger size, which have been outside the scope of this inquiry.

5. The medical conclusions are in accord with those arrived at from the chemical and physical data, and prove conclusively that the choice between the two systems of lighting does not depend upon hygienic considerations.

The Lighting of Streets and Public Buildings.

DEMONSTRATIONS OF ILLUMINATION MEASUREMENT.

(*Special Notice issued by the Honorary Advisory Council.*)

THE question of public lighting is one of the problems of the day, not only in regard to the comparative merits of different illuminants, but also in regard to the amount of illumination required for different purposes. The latter aspect of the subject is of great importance, as it involves the question of necessary or superfluous consumption, which again resolves itself into a matter of finance affecting the ratepayers of the district.

In order to contribute something towards the solution of this difficulty, and to endeavour to obtain some authoritative data on the question, the Hon. Advisory Council of the Municipal Exhibition have specially arranged with Mr. Leon Gaster, the Editor of *The Illuminating Engineer*, whose well-known views are sufficient to ensure impartiality and absence of prejudice, to superintend and direct a series of demonstrations at the Royal Agricultural Hall during the Exhibition, with the latest apparatus available, for the measurement of the illuminating power of different illuminants now in use.

The appliances used will consist of the most recent types introduced in this country, and, it is hoped, of those in use in America and the Continent. As the subject is one of the utmost importance and interest to all users of illuminants, the demonstrations will be of considerable value to all municipal authorities and others engaged in the lighting of streets and public buildings.

Electricity v. Gas for Illuminating Purposes.

BY A CORRESPONDENT.

A DISCUSSION on the subject covered by the above title took place at the Municipal School of Technology, Manchester, on February 25th. This meeting was organized by the Manchester Students' Section of the Institution of Electrical Engineers, whose members championed the electrical cause, and had as guests the members of the Manchester and District Junior Gas Association to defend the gas interests. Prof. Harold B. Dixon, M.A., F.R.S., F.C.S., was in the chair, and a gathering of youthful enthusiasts followed the points brought out by their various spokesmen, an earnest and entertaining debate resulting, a number of lantern-slides being shown by those taking part in the discussion.

After the general rules of the debate had been explained, these including costs on a rough basis of 3*d.* per B.O.T. unit for electricity, 2*s.* 6*d.* per 1,000 cubic feet for gas and the use of British candle-power, the case for the electrical men was opened by Mr. D. L. Sands.

He realized his responsibility in undertaking to open a debate of the nature, and did not propose to indulge in unreserved slander of the gas side. There were the two important sources of light energy for the consideration of the engineers present, and in each system only a small portion of the energy supplier was delivered in visible rays, the maximum proportion with a gas-flame being about 20 per cent.; whilst it was within the range of possibility to obtain as much as 60 per cent. by the use of electricity. About two-thirds of the energy supplied to an incandescent gas-burner was used in heating the nitrogen of the air alone. Diagrams were thrown on the screen, plotted from the recently obtained results of experiments by an eminent authority, showing the light efficiency of our common sources of energy, which proved that the flame-arc was the best in this respect, being followed by the mercury vapour lamp and other electric types, the various forms of gas-lighting being well in the rear, close to petroleum. The new metallic filament lamps would do as much for electricity as the incandescent burner had done for gas, and from actual results in ordinary domestic use proved cheaper than the best gas-lighting. Mr. Sands quoted figures showing that flame arc lighting was far superior to and cheaper than gas. Altogether the electrical prospects in the lighting world were very promising.

Mr. Franklin Thorp followed with the gas arguments, and claimed that the advantages, for cleanliness, safety, and convenience of "our trusted friend gas" were greater than of that "dazzling though fickle" electricity. A slide was shown giving the challenge thrown out by a leading firm of gas-mantle makers to the metal filament lamp people, a challenge, he said, unaccepted, for reasons with which they were quite willing to agree. Comparing the costs of the two systems, he stated that for 1,000 hours equal illumination, including replacements, electricity would total 14*s.* and gas 3*s.* Another slide portrayed the instructions issued by the electric filament lamp makers, such as "do not burn lamps at angles from the vertical, or in vibratory positions without spring holders; do not clean while burning or switch on immediately after cleaning;" and concluded with his own advice: "Do not bother, use gas." On high voltage circuits Osram lamps could only be used in series, needing careful pairing, whilst the series depended on the behaviour of a single lamp. He reckoned the cost of new Osram lamps at 4*s.*, and gas-mantles at 6*d.* each. The cost of installing he calculated at

8*s.* per point for electricity, and 3*s.* 6*d.* per point for gas. On the points of distribution and intrinsic brilliancy of light gas had the advantage.

Mr. John Roberts renewed the electrical arguments, and gave figures showing the costs of the respective systems in which the electrical compared quite favourably with the gas. Some recent results, instanced by Mr. hygienic point of view electricity was much preferable, as incandescent lamps did not emit noxious fumes or consume oxygen, as all gas-lamps undoubtedly did. The deleterious effects of the use of gas-lighting were especially noticeable in shops, causing discolouration and perishing of goods, whilst efficient lighting of air-tight show-cases, so necessary in some businesses, was only

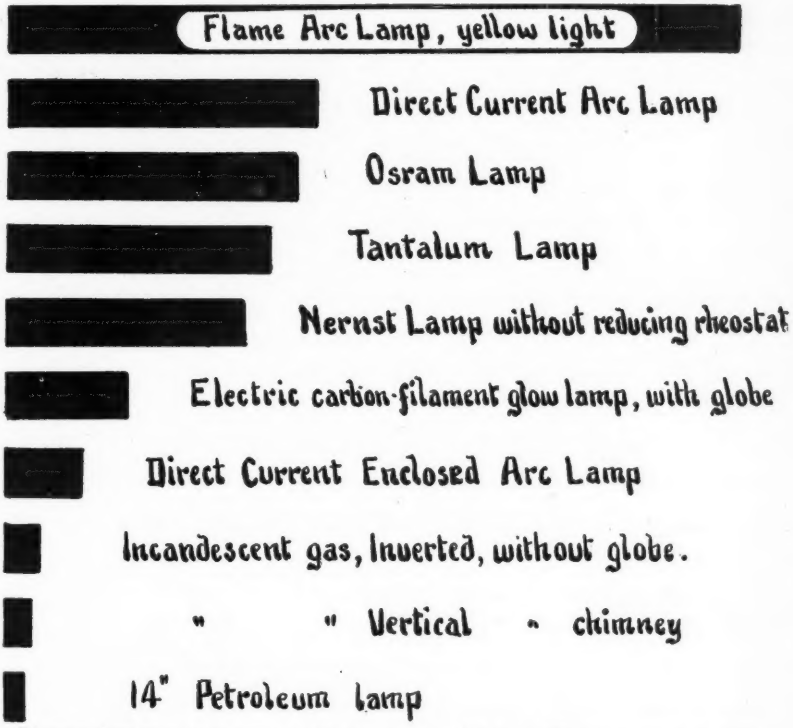


Diagram showing relative amount of light energy evolved from different sources for a unit supply of fuel.

Seabrook of West Ham, and obtained from reliable and independent sources, showed that electrical was quite as cheap as gas-lighting in cost of energy alone. Combating the figures of previous speakers, Mr. Roberts claimed that a number of the figures put forward by gas advocates were exaggerated, and pointed out that lamps were intended for illumination, and not for staring at. From an possible with electric light. The damage to decorations and the cost of cleaning were faults to be laid to the gas side, and should be reckoned with in making comparisons. For up-to-date efficient lighting in new buildings electricity was always chosen, as witness the magnificent institute in which the meeting was held.

Mr. J. Alsop continued for the gas interests, and gave a number of figures

for mill and street lighting, all showing gas to be the cheaper. In one case, totalling up the capital cost, and including the cost of the generator on the electrical side, gas had an advantage of 279*l.*, and 110*l.* in annual expenditure. An all-sufficient light was obtained from incandescent mantles, and these were being largely adopted. Many of the new mills being erected in Lancashire were adopting gas, and as heat was required in cotton-mills to enable the operatives to satisfactorily perform their duties, gas, which gave heat as well as light, was here advantageous. In one case where metallic filament lamps had been installed their use had been discontinued on account of breakages, and gas used instead. For street lighting he claimed that gas was cheaper, and in proof of this he quoted a number of costs of the different systems obtained from various towns. In Queen Victoria Street the cost of electric lighting was 825*l.*, against 540*l.* for gas, per annum, whilst the costs at Victoria Station and in other places were in favour of gas illumination.

Another electrician followed, in the person of Mr. L. H. A. Carr, B.Sc.Tech., who pointed out that the figures given by the previous speaker were quite meaningless without details of the basis on which the two systems were contrasted, on which no information was given or apparently considered. In comparing mill-lighting and similar cost the expense of cleaning and redecorating had to be included, and also the results of the injurious effects on the health of workpeople, on which points electricity scored. In street lighting commonsense and economy were on the side of electricity, and the expense of replacing the easily broken mantles, and the inconvenience of loss of light in the meantime, were great points against gas. In private houses gas caused much more work and annoyance, whilst in shops electricity gave better results without the damage to and loss of stock caused by the heating and fumes of gas. Electricity was safer inasmuch as no evil after effects were possible, as when taps were accidentally left on after a temporary failure of the gas supply. The flickering light noticed with gas burners also had an injurious effect upon the sight, especially after enforced continuous use.

Further championship of gas came from Mr. D. V. Hollingworth, who stated that the alleged fouling of the atmosphere by gas burners was of small account, and that the heat given off had a ventilating action, carrying away any impurities created. No CO or acetylene was formed; CO_2 was not poisonous, and was permitted by the Board of Trade, as their regulations stipulating the amount allowable showed. These arguments against gas-lighting should be used equally against an ordinary coal fire. All SH_2 was removed in process of manufacture, being an important and profitable by-product. Gas-lighting had been adopted at the Birmingham Art Gallery on the advice of Prof. Frankland. Electrical generating stations were far greater sinners in the matter of injurious exhalations than gas-burners or than gasworks; whilst flame-arc lamps give off hydrofluoric and hydrochloric acids and nitrogen oxides, which render them unemployable in enclosed spaces.

Mr. A. E. Jepson pointed out other advantages of electric light. Reverting to the previous speaker's remarks on the gas lamps adopted in the Birmingham Art Gallery, he quoted a letter from the City Electrical Engineer of Birmingham, showing that these lamps were only used in a case where there was a domed roof and it was possible to fit direct ventilating shafts, and that in other cases in this gallery the valuable pictures were directly illuminated by electric lamps.

Dealing with the question of reliability, Mr. C. E. Teasdale said that an accident to a gas main could be patched up temporarily or a by-pass used and the supply be continued, whereas an electrical misfortune needed immediate attention, and could be easily caused, the dropping of a spanner across two terminals in a station being sufficient to throw a town into darkness. He also claimed that the owners of every building, when installing electric light, put in gas fittings as a

standby, a remark followed by a mock and unsuccessful search on the part of the electrical men for the gas-fittings in the room of meeting. Electrical meters, too, were more unreliable than those of the gas type, and were not subject to official certification as were gas meters, though he gave figures to show the proportion of incorrect electricity meters discovered in a series of tests by the L.C.C.

On the other hand Mr. W. Browning considered that electricity was more reliable than gas, especially in theatres and similar locations, and after a stoppage the supply could be resumed without the trouble and ill-effects consequent upon a like gas failure.

Where lights were left burning in bedrooms this might be a serious matter, resulting in suffocation and explosions. As against Mr. Thorp's list of "don'ts" for electric lamps, he gave a number for gas mantles, and concluded with "Don't forget your matches."

Mr. James Taylor, in speaking of the dangers of either system, pointed out that gas did give warning of any escape by its odour, whereas electricity was not noticeable. the danger of electricity being admitted, and regulations for its control provided by the Institution of Electrical Engineers and the Fire Offices, which precautions were not considered necessary with gas.

Replying to Mr. Hollingworth's remarks *re* the Board of Trade limit for CO_2, Mr. J. L. Lovell claimed that as there was no help for it, they just had to allow as little as possible, and quoted the Home Office regulations for workrooms, &c., where artificial illumination was employed, which call for 400 cubic feet of space for each person, unless electric light was used, when only 250 feet was considered necessary. Electricity was the only lighting medium possible in many of the modern industries where naked lights would be dangerous. With reference to Mr. Thorp's figures for relative costs of fitting and subsequent claim that with the use of the new gas switches convenience equal to that of electricity was obtained, he quoted the makers' advertised price of "from 6*s*. 6*d*. each," which put up the cost of gas-fitting to 10*s*. per point, as against the claimed 8*s*. for electricity.

Mr. H. D. Symons, Mr. A. H. Holton and Mr. W. Hanna also spoke, and then the Chairman brought the meeting to a close.

He congratulated himself upon being present at such an "illuminating debate," and whilst not attempting to follow all the figures put forth, thought they had been given with not more than usual exaggeration. From a point of oratory he thought the gas speakers, perhaps naturally, had the better, whilst in "abuse" honours were even. Both systems had advantages, and their adoption depended upon local conditions. Shopkeepers did and would use electric light, which was certainly a boon in decorated rooms. Although arc lamps did emit impurities, gas vitiated the atmosphere more than electric light, but the heat could and should be used for ventilating purposes. In his own house he used both systems, in the best rooms electricity being installed, which he thought better for ordinary lighting, whilst in the bedrooms, for convenience, and the billiard-room, where light, heat, and ventilation were wanted, he used gas. He had not been moved by any of the arguments for cost, and considered that although gas might be somewhat cheaper, electricity had certainly compensating advantages. In conclusion, he quoted a parody on Dryden's well-known lines :

> "Let gas and glow-lamp share the prize
> And both divide the crown.
> This raised a fossil to the skies,
> That drew the lightnings down."

A hearty vote of thanks was accorded to Prof. Dixon for his services as chairman, and the meeting closed.

Owing to the late hour, and to disperse the combatants at the conclusion, the school authorities cut off the light, when accumulator pocket-lamps carried by some of the electrical men had an opportunity of proving their worth, and came gallantly to the rescue.

The Jandus Regenerative Arc Lamp.

By A. Denman Jones.

This is the first commercial lamp to use chemically treated carbons burning in an airtight enclosure. It is well known that the ordinary enclosed arc has almost displaced the open type pure carbon arc lamp, on account of the saving due to the long burning hours of the enclosed lamp, despite the fact that the light efficiency of the enclosed lamp is less than that of a similar open type lamp.

On attempting to solve the problem of the enclosed flame or chemical arc several main difficulties occurred.

Flame carbons, if burning in an ordinary enclosure, give a dense white deposit upon the sides of the glass enclosure, sufficient to entirely cut off the light after a few hours' burning.

The ordinary chemically treated carbon would also only give its efficiency if exposed freely to atmospheric air.

It was also realized that little economy would be effected in the cost of the carbons unless the chemicals necessary for operation were greatly reduced in amount, as the open type flame lamp will burn several ounces of chemically treated carbon per hour.

The problem was eventually solved by enclosing the arc in a cylindrical glass vessel, with side tubes giving free communication between the top and the bottom, this system of chambers being arranged as an airtight enclosure. The carbons of the lamp are placed in the inner cylinder. The chemically treated carbon is positive, and placed at the bottom, and consists of a high grade carbon core of star-shaped section, the inter-spaces between the rays of the star being filled with a special chemical composition, consisting of a mixture of calcium tungstate and calcium fluoride, together with steadying salts of sodium and potassium.

The inner glass cylinder is surrounded by an outer opalescent glass globe, to ensure good distribution of the light.

The heat of the arc in the glass cylinder produces a strong upward draught of heated gases, which descend downwards through the side tubes, and pass up again through the central glass cylinder. The passages are so arranged that the walls of the glass cylinder are swept by a rapid current of hot gases. Under these conditions it is found that the fumes are not deposited upon the glass walls, but the deposit mainly occurs in the chamber above the glass cylinder, from which it may be easily removed when recarboning the lamp.

The rapid circulation has also the effect of carrying the majority of the chemical vapours given off again and again through the arc, serving to regenerate the chemical vapours therein. The success of this regeneration may be gauged from the fact that less than 15 grains of chemicals are consumed per hour, the carbons giving off only sufficient fresh chemicals to compensate for such chemical vapours as are condensed in the chambers.

It will be seen from the sectional illustration of the lamp that arrangements are made by means of a coned block at the bottom of the lamp to withdraw the inner cylinder and carbon for recarboning without disturbing any other part of the lamp. The cone is clamped tight by the winged nut at the bottom.

Under usual conditions 70 hours' life is obtained from one pair of carbons. The lamp operates at a current of 5 amperes with 100 volts on the lamp terminals, including resistance, and may be burned any number in series at 100 volts apiece per lamp.

The upper electrode is a plain carbon.

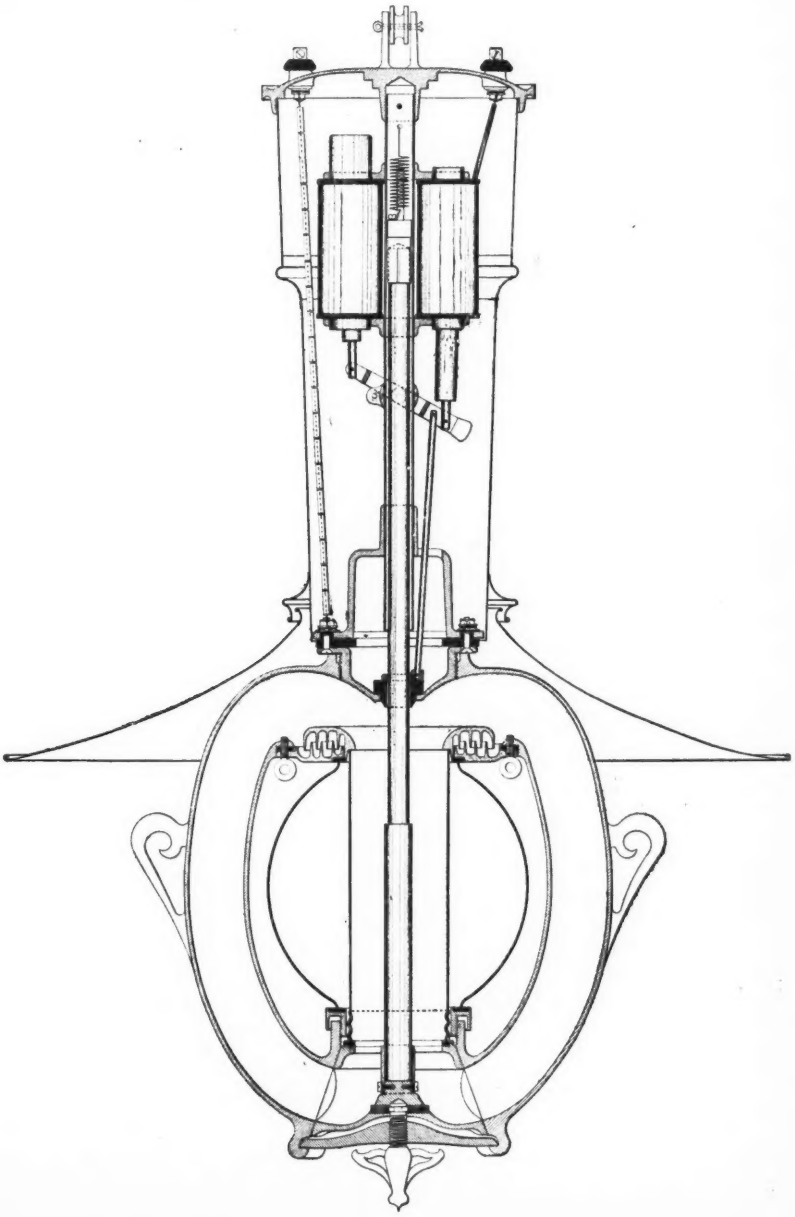


FIG. 1.

SECTIONAL VIEW OF JANDUS ARC LAMP.

The core of the bottom electrode being also of carbon, and the current of the lamp low, the voltage drop across the carbons is less than 1 volt. Variations of light due to varying carbon resistance do not therefore occur.

The combination of chemicals mentioned above gives a light of very great efficiency, of a brilliant but pale yellow colour, somewhat similar to sunlight or incandescent electric lamps. The spectrum of the light shows bands throughout all the colours, from deep red to violet. This polychromatic light therefore gives good colour values in tinted fabrics; the distorted effects sometimes seen from monochromatic illuminants do not occur.

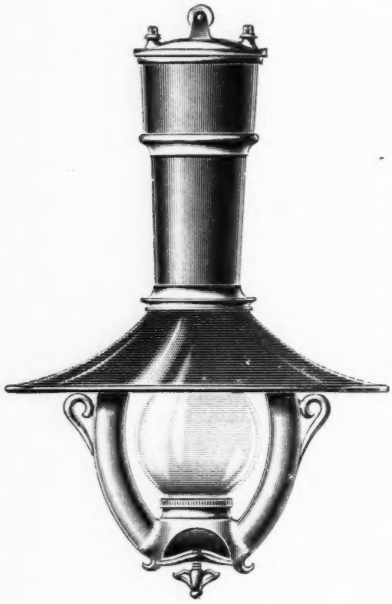


FIG. 2.
General View of Jandus Arc Lamp.

The mean hemispherical candle-power for a 500 watt lamp is 2,500.

The globes and reflectors are so arranged that the diffusion is sufficiently good to prevent any shadow, even at a distance of 1 ft. directly under the lamp.

The arrangement of the carbons gives a long vertical arc; almost the ideal shape for efficient distribution of light over a wide area.

The maximum candle-power occurs at an angle slightly below the horizontal. The candle-power vertically below the lamp is considerably less. This tends to distribute the amount of illumination over a very large space without the lamp being hung at an excessive height.

The most interesting feature of the lamp is, perhaps, the method of preventing the deposit upon the inner glass cylinder. This method, as outlined above, consists essentially of producing an even flow of gaseous vapours through the glass cylinder, sweeping the walls of the cylinder with a rapid current, and without the production of eddies within the cylinder. Should eddy currents be produced, rapid deposition of the chemical products would occur. If, for instance, the inner cylinder is omitted, and only the outer globe used, although the surface of the outer globe is considerably greater, it would rapidly become covered with deposit, due to the production of local eddy currents within the globe. It will be seen that the chamber above the inner cylinder tends towards the production of eddy currents therein, and it is at this point that the fumes are deposited.

Junior Institution of Engineers.

SIR WILLIAM HUGGINS, K.C.B. O.M. D.C.L. LL.D. F.R.S., has been elected Vice-President of the Junior Institution of Engineers, in succession to the late Lord Kelvin; also Sir Archibald Geikie, K.C.B., F.R.S., and Prof. J. J. Thomson, F.R.S., have been elected.

The first Local Section in connexion with the Institution, now numbering over a thousand members, has been established at Birmingham, with Mr. F. S. Pilling as Chairman, and Mr. R. B. A. Ellis, of 67, Wordsworth Road, Small Heath, Birmingham, as Hon. Secretary.

SPECIAL SECTION.

Lighting from the Architect's Point of View.

By G. A. T. Middleton, A.R.I.B.A.

It is unquestionable that a period of exceedingly brilliant illumination of the interiors of buildings is with us now, and is certain to remain, beside which no previous period in the world's history is comparable. The architect, whose art is historical, dating back to the earliest times, and whose modern work is based upon tradition thus handed down to him, is consequently bound to reconsider his position in designing his interiors.

On the other hand, he claims that the illuminating engineer should respect the traditions of his craft, and, while providing the degree of light which modern requirements demand, that he should do this in such a way as not to interfere with systems of enrichment which have become stereotyped. Both architect and engineer are right, and consequently there must be a certain amount of give and take between them. Speaking generally, the architect demands that light should be diffused rather than concentrated, so that there may be no harsh and unnecessary shadows where they are not desired. This demand is unquestionably due to tradition, for, from the earliest ages onwards, the lighting of interiors has hitherto been dim, and their decoration has been evolved upon this basis. Traditional forms of decoration are slow to change, and consequently it is reasonable to expect the architect of the present day, when confronted by an entirely new conditions of affairs, to ask that he shall be let down gently, and allowed plenty of time in which to conform to the new state of things.

The architect learns his business by studying the old, the engineer his by studying the new, and the two professions are thus in sharp conflict; but when the problem is that of lighting an old building, the new must surely give place to the old. Most old buildings in England are of the character of churches, erected in the great Norman and Gothic times lying between the Conquest and the Reformation.

The buildings of those days were, internally, at any rate, designed with little idea of brilliant illumination. Certainly, towards the later period, a great deal of light entered in the daytime through the large windows, but these were intended for the display of stained glass rather than for the admission of daylight. The general internal effect was sombre, and it was deliberately so, and this in spite of the fact that night-time services were frequently held, for which the only illumination consisted in a few candles near the altar, the effect of which was but to intensify the gloom. Yet how beautiful the result must have been can well be comprehended by any one who has attended a twilight or night service in a great continental cathedral such as that of Cologne, where a silent congregation stands in the huge nave listening to, though not taking part in, the music and the prayers.

No wonder, therefore, that the cry in respect to the Gothic churches is for a system of lighting which shall respect an architecture designed under such conditions. Glaring electric lights or incandescent gas lamps, centrally suspended along the nave or placed on stands, are exactly what are not required. They may give ample light to enable members

of the congregation to read hymns printed in small type, but even so, they are generally irritating to the eyesight. In some way or other the source of light should be concealed. The lamps are preferably more numerous and of lower power, placed, for instance, above the capitals of the shafts or suspended with a dish below them, to reflect the light upwards instead of downwards, and so allow it to spread evenly.

Of course, more illuminating power is required if this sort of thing is done, and where economy is a great consideration, as it often is, the more obvious plan of exposing the light may have to be resorted to, but even this might be subject to a great deal more care and discrimination than is usual. The light above the pulpit, for instance, need not necessarily blind the preacher or throw his face entirely into shadow, and in no case is there any reason why the filaments of incandescent lights should be visible through clear glass.

In the case of new buildings the positions are somewhat reversed. The architect can then, at any rate, consider his method of artificial illumination at the same time that he is preparing his plans and provide accordingly; in fact, all careful architects do so. The style in which they are working may be controlled by other circumstances, yet it is undoubtedly recognized that places which are to be brilliantly lighted, such, for instance, as theatres and restaurants, ought to be designed in brilliant colour, trusting to surface decoration in polychromy and gilt rather than to moulding and carving. This follows tradition, being according to the rule which allowed this sort of thing to be done in the Byzantine, Moorish, and Indian work executed in countries where the sunshine is most brilliant.

Under such circumstances, too, it is unquestionable that classic forms are more suitable than Gothic, and for the same reason, that the classic styles developed in the brilliantly lighted lands of Greece and Italy, while the Gothic arose in the duller countries of the north. We may even go so far as to say that the highly refined work of Greece was only possible in a land where the sunshine was extremely bright, and that, given similar artificial conditions of high illumination, we should do well to use the same extreme precision of workmanship and delicacy of form as did the Greeks, combining with these the use of that beautiful material which so largely assisted them. For this reason low relief work in highly polished marble, or even in plaster, looks exceedingly well in an electrically lighted hall, while much elaboration in high relief appears vulgar and gaudy.

To the great majority of us it is, however, domestic work which is of the greatest interest and importance, for while we may occasionally spend a few hours in large buildings, we most of us live our lives in offices or homes. Here, again, the tendency of the moment is towards too obvious lighting, placing high candle-power lamps, for instance, over the centre of the dining table, when several of lower power placed round the room would enable everything to be seen quite as distinctly and with much less strain upon the eyesight.

It is certainly no essential part of one's comfort to be dazzled during meal-times, while the central light is one of the most inconvenient if the room be used for other purposes, such as for reading or for working. Whatever be the employment, and perhaps most of us use our dining-rooms for general purposes, the great need is that the lamp shall not be placed in front of the eye. On a winter's evening one naturally turns to the fire, and the lamp should then be arranged in such a position as to throw light upon the printed page or the piece of needlework, and from behind the shoulder yet not behind the head.

Similarly in a drawing-room it is necessary to select the position of the lamps to suit the furniture, the piano in particular requiring attention. A central light is obviously absurd, for if such be the only means of illumination, the piano has to be placed with its back against the wall,

while the singer interposes his person between the light and the music. Wherever music is really loved, as it is in most families, it is well recognized that the singer should face the room. This to a large extent controls the position of the piano, which has also to be regulated by such essential matters as keeping it out of a draught and in a position where the temperature will be uniform. An architect, in planning a room like this, will always, if he is wise, obtain information as to whether a cottage or grand piano is to be used, and will arrange a place for it, thinking last of all of the source of artificial illumination, which must be chosen to suit the piano and the other features of the room.

The common mistake made in bedrooms is again that of not recognizing where the light is required in relation to the furniture, particularly when electric lights are used. The dressing-table in particular requires attention, and is best lit by several small lights or a diffused light, which will give a good reflection from the looking-glass, both of the front of the face and of the back when a hand-glass is used. With regard to the bed, the light is commonly suspended over the centre of it, where it is most trying in case of sickness. The right position is against the wall at the back, so as to throw the light upon any book which the invalid may wish to read, and not into his eyes.

Throughout the house the same rule applies, that many low-power lamps are preferable to a few of high-power, and that diffused is generally better than concentrated lighting. This is more particularly the case with regard to the decorative effects, giving much more opportunity for the architect to display his skill as well as for the owner to arrange his furniture and hangings with good results.

A clever designer can, however, utilize modern artificial lights to enhance the beauty of his work. He can show his light or hide his light just as best suits his design, or throw it by means of shades and reflectors in any direction which he may desire. The effects produced may perhaps be a trifle theatrical, but there is no real necessity why they should be so if the architect really possesses the artistic instinct. All of us, though often unconsciously, recognize the difference between a room which is artistically lighted and one which is not, and we all appreciate the value of gradation. This it is that the artist must seek, combined with occasional sharp contrast, if he is to succeed in properly lighting an interior. Uniform monotony, even the monotony of brilliance, is scarcely ever satisfactory. There is always a temptation to an amateur in the matter to so arrange his lights that there is no shadow or shade or difference of tone, but while doing this he is destroying all delicacy of effect and everything that goes to produce a perfect picture.

Reverting once more to the case of great churches already alluded to, how much more peaceful, how much more solemn they are when certain parts are thrown into gloom, than when all are brilliantly lighted! Shadows give a sense of mystery, and tend to restfulness. It is only very occasionally that uniformly brilliant light is needed, as in a ballroom or a opera-house on a gala night; and even in the ballroom there is no reason why, in regard to the gallery, if there be one, the space beneath it should not be allowed to rest in its normal shadow, and the gallery above more dimly lighted than the rest of the room.

If something of this sort be done the beauty of the scene, instead of being detracted from, is enhanced by emphasis. On all points, therefore, it is well that an architect who designs a building should control its lighting also; but he must do so with knowledge and understanding, and in full consultation with those who know best the peculiarities of the system of lighting which it is intended to adopt.

The Relation of Illuminating Engineering to Architecture, from the Engineer's Standpoint.

By E. L. Elliott.

(Abstract of Paper read before the Illuminating Engineering Society, the 12th of March, 1908.)

The dwellings of our remote ancestors were probably of the very simplest description; they were merely huts or caves, intended for the individual dweller, and requiring only individual effort. With the development of such rude shelters into more elaborate dwellings the co-operation of a number of individuals was needed. Co-operation invariably requires leadership. Where the work of more than one individual is directed to a common end, there must be a director. Thus, in the development of building, there came a time in its very early stages of development when a master-builder was a necessity. The word "architect" is merely the Greek equivalent of master-builder.

The fundamental purpose of the architect is thus disclosed, namely, to plan and direct the construction of a building so that as a whole it shall fulfil all the purposes for which it is intended. Herbert Spencer has shown that the æsthetic instinct takes precedence of the desire for protection in the evolution of dress; and while the same order can probably not be shown in the evolution of building, it is certainly true that the desire to decorate was very nearly contemporaneous with the ability to build. Thus, almost from the beginning, building involved two theoretically distinct elements, namely, Utility and Beauty. These two elements, however, were practically connected; and thus the architect became not only the mere director of labour, but the originator and arbiter of art as applied to building.

In the advance of civilization it came about that structures were frequently erected in which the artistic or æsthetic elements predominated. Such buildings were intimately connected with the religion of the time, or with the government, or with both, which were generally closely allied. The æsthetic effect served an important purpose in impressing the people with the authority of their government and religious institutions. Some of the few remaining portions of early structures of this kind, in point of grandeur and beauty of conception, and even in skill of execution, have never been surpassed. They were wonderful embodiments of the highest degree of artistic taste and originality, coupled with the lowest form of human labour. Massive blocks of stone were quarried and hauled comparatively long distances, and fitted into their prescribed places with consummate skill, so far as the actual results were concerned; but this was accomplished with a total disregard of human life....The substitution of the forces of nature for the mere brute force of the human muscles is an entirely modern development. The utilization of natural forces to accomplish what had hitherto required the muscular power of human beings, is the foundation of modern engineering....Strictly speaking, there are no remnants of any ancient structures which show the application of true engineering principles; for engineering implies not only the achievement of results with the minimum of material and labour, but a degree of classified knowledge which enables the engineer to predetermine accurately the exact amount of any given material, and the form necessary for it to take in order to secure these results. Such knowledge belongs only to modern civilization.

What we term "modern civilization" is characterized by its extreme complexity as compared with ancient civilization; and this complexity is largely the result of a vastly greater knowledge of natural phenomena. In a single century we have learned more of the workings of nature than had been found out in the entire previous existence of mankind. The result of this has been to transform the large majority of human beings from mere engines of force into sentient creatures, who are thereby free to develop those mental powers which lift them above the animals. As a direct consequence of this emancipation, the human family is on a vastly higher plane of intelligence and general happiness....

Even admitting that we have less commanding geniuses in the field of art than may have existed in the palmiest days of Greece and Rome, it is indisputable that the total amount of artistic appreciation among the masses of people is incomparably greater; and it is the scientist, the engineer, that has brought this about.....

Ancient and modern civilizations have scarcely a single important element in common, barring the elemental human passions, which never change. There is scarcely a phase of life which is not essentially different to-day from what it was in ancient and mediæval times: and this radical difference is, and by rights ought to be, exemplified in modern building. In Greece a philosopher gathered such people as had the time and disposition to hear him beneath the shade of a tree, and expounded his doctrines. The modern counterpart of this is the University, with its millions of dollars' worth of buildings and equipment, its thousands of students, and its hundred of instructors and professors. In place of the parchment scroll we have the daily newspaper, produced at the rate of several thousand complete copies an hour. These two instances give a fair measure of the all but infinite space between the old and the new. And yet the modern architect seems to have but one anchorage in which he has implicit faith, and that is veneration for antiquity: when he casts loose from his he drifts and tosses about, and knows not whither to direct his course. He dare not discard the parchment scroll, but would have it printed on a rotary press. Appreciating the simple beauty of the monolithic column, he strives to attain it with steel beams, hollow brick, and cement. Inspired by the majesty of the Gothic arch, he reproduces it in lath and plaster.

The habit of clinging to past forms of architectural expression is not infrequently carried to the point where it becomes ludicrous. The wind-swept island of Great Britain naturally developed a type of cottage having long stretches of sloping roof, designed to keep the whole structure as near to the ground as possible. As this developed in the very early period of the art of glass-making, the windows of necessity were divided into a large number of small panes. Incredible as it may seem, one of the first so-called "sky-scrapers" to be erected in New York was modelled after this type of cottage. The building is still standing at No. 1, Broadway, and has the distinction of being the only "Queen Anne" office building in the metropolis. On the other hand, the pointed arch, the succession of long vertical lines, and the versatility of adornment, which are the basis of Gothic architecture, and which would lend themselves to modern building with comparatively little violence to the original spirit of conception, have been only recently attempted, and then only in a timid and half-hearted manner....Eliminate the evidences of ancient and mediæval architectural features, and what have we left to represent modern civilization?....

The simple truth is that modern civilization has not yet expressed itself in architecture. Were our nation to be suddenly blotted out-to-day, the structures which would most adequately portray its habits of life and planets of thought would be our engineering works —our bridges and tunnels, our railways, mills, and factories. In point of beauty some of our modern bridges may be put along with any architectural structure of antiquity. True, the beauty is of quite a different type; but so was beauty of person of a different type in ancient times.

Reduced to its lowest terms, the business of the engineer is to produce a given physical result with the minimum of material and labour; and the justification for his vocation must be found in the extent to which he can accomplish this end. Emerson has defined beauty, taken, of course, in its physical and material sense, as "that which has no superfluous parts, which exactly fulfils its purpose." In following this definition the work of the engineer is beautiful to exactly the degree that it is efficiently done. Broadly speaking, the modern building is simply an aggregation of utilities. With very few exceptions it is simply a part of a vast machine—a machine being properly defined as any device which enables a man to accomplish more or better work than he could do without it. Apply this at random and see how well it fits. The factory building exists because it enables work to be done that could not be done at all in the dwelling, or that can be done to better advantage; and it is as much a fundamental part of the apparatus for producing the particular articles made as is the engine or machinery. So the office building is merely a device by which the various operations of accounting and commnuication can be efficiently carried on; and so with the store, the school-house, and, to a large extent, even the dwelling. Almost the single exception is the church; and this, from being almost the only form of public building, has become a

comparatively infrequent and inconspicuous structure.

Building to-day has, therefore, become almost entirely an engineering problem; and with the vast increase in the complexity of life which characterize modern civilization has arisen the necessity of subdividing the general problem of construction into a number of distinct branches. Among these are the purely mechanical construction, which has given rise to structural engineering; the methods of heating and ventiiating, with its special engineering; electrical equipment, with its electrical engineering; provisions for sanitation, with its sanitary engineering; and, lastly, the necessities for artificial illumination, demanding illuminating engineering. All but the last mentioned of these special branches of engineering have gradually been necessitated in the evolution of building, and have been accepted by both architect and client. It is only the last that is still to some extent in the undeveloped state.

Accepting the formula already given as to the general field of engineering, we arrive at the fundamental proposition that the business of the illuminating engineer is to produce a given or required result of illumination at the minimum outlay for the original installation, and subsequent maintenance cost. This leaves one highly important question still to be settled, namely, Who shall determine what the required illumination shall be? Evidently this question must be decided jointly or separately by the three parties to the contract, namely, the owner or client, the architect, and the illuminating engineer. It may be stated without fear of serious contradiction that the owner has fully met his responsibility in the premises when he has clearly set forth the exact uses for which the various parts of the structure are to be put. It then lies between the architect and the illuminating engineer to determine what the best illumination for each and every particular case may be. As between these two parties, the greater economy of thought and labour will be secured by placing the responsibility upon the illuminating engineer. To determine just what manner of illumination is best for all the numerous and widely varying conditions of modern life requires an extent of technical knowledge, and a breadth of experience which the architect may very appropriately and wisely avoid, providing the results can be obtained from other sources. It is simply a matter of division of labour and economy of human effort. Modern civilization demands that the individual shall be able to do some one thing completely and well, and shall not spend his time in doing things which he can only do indifferently, and which others can do more efficiently.

Benjamin Franklin used to set his own writings in type, put them in the press, and take a hand in running off the printed sheets; and even Horace Greeley was in the habit of going to the cases and setting up his own editorial in his early days; but this was not true economy of human effort. There was many a one who would have been glad of the job of setting the type, whose written productions would have been of infinitesimal value. Surely the architect of to-day has a sufficiently wide and dignified field for his labour in the legitimate work of unifying and harmonizing all the diversified elements that enter into a building, without bothering his head about the infinite details of these different elements.

The advent of the illuminating engineer as a specialist should be hailed with greater delight and relief by the architect than by any other member of the community. Having satisfied himself of the competency of the illuminating engineer, just as he would satisfy himself of the competency of the electrical or construction engineer, the architect can turn over the plans of the building, with the specifications of the use or uses to which it is to be put, and probably also a statement of the illuminant to be used, and leave the entire technical problem to the illuminating engineer. On the other hand, the illuminating engineer must have authority commensurate with his responsibility. The architect would not think of arbitrarily changing the specifications of a structural engineer without his full consent, and for the same reason the plans of the illuminating engineer should be equally respected.

There is one difference, however, between these two branches of engineering as connected with building; the skeleton of a building, which is the work of the structural engineer, is hidden when the work is completed; but the apparatus especially connected with the illumination is not only in plain view, but so conspicuously in sight as to form one of the necessary elements in the artistic whole. This phase of the problem of illuminaton, therefore, falls within the legitimate province of the architect. There is clearly but one solution of this apparent clash of authority, and that is co-operation between the architect and the engineer. The engineer demands a certain physical result; the architect demands certain

structural features or conditions in order to produce the general harmony of result which it is his business to secure: how shall these two demands be reconciled? Evidently there will be a large number of cases in which no reconciliation will be necessary; all that is required will be such a versatility on the part of the engineer that he can design the physical part of the installation so that it will produce both the physical and artisic results demanded. It is conceivable, however, that cases may arise in which the artistic conditions required by the architect can be secured only at a greater or less sacrifice in economy: the decision then very clearly rests with the client. The possibility also still remains of the architect specifying certain conditions which he considers essential from the artistic standpoint, but which the engineer deems not only uneconomical, but positively detrimental in point of the resulting illumination: who then shall decide? In this, as in all other cases, the client is the court of last resort, on the generally accepted theory that he who buys an article has a right to dictate as to its character. If a man chooses to work by light which is dangerous to his eyes, or is ill-suited to the purpose for which the illumination is required, for the sake of the supposed artistic effect, he can hardly be denied his right to such a course, however foolish it may seem to the engineer. Such cases, however, are hardly likely to occur under proper conditions. There are few persons who would willingly subject their eyes to a dangerous strain, or handicap the efforts of themselves or their employes by bad light after having been duly warned.

Since the larger proportion of buildings at the present time are predominantly utilitarian, there is extremely little opportunity for any disagreement between the illuminating engineer and the architect. In all this large majority of buildings the general artistic talent of the illumination engineer should be sufficient to avoid such breaches of taste as would be objectionable. This class of building includes factories of every description, office buildings, school-houses, and the larger portions of hotels and public buildings. In the case of a large number of residences the illuminating engineer should also be competent to lay out, or pass upon every feature of the installation. There remain then only the more pretentious class of dwelling-houses, churches, theatres, and, to a partial extent, libraries and public buildings, in which co-operation of engineer and architect is essential. In these cases the artistic features of the lighting installation are of such importance as properly and justly to demand the attention of the architect. However, while the architect is properly the arbiter in such cases as to the artistic side of the problem, the services of the illuminating engineer are no less valuable than in the other cases. Let it be clearly understood that art as applied to architecture does not exist for its own sake, but is only directed to the embellishment of the necessary and essential physical features of the building. Good decorative art is not only compatible with an efficient physical result, but can be considered of the highest order only when it conforms to good mechanics—in fact, decorative art rests upon a purely scientific basis.

A careful analysis of the respective provinces of the illuminating engineer and the architect, therefore, disclose no more ground for mutual disagreement and distrust than between the architect and any other engineering specialist. The passive or active antipathy which has thus far existed to a greater or less extent on the part of the architect toward illuminating engineering, appears to be wholly unjustifiable; and it may be worth while to seek the reasons for this apparently groundless opposition. The most obvious cause of this feeling may undoubtedly be found in the fact that the illuminating engineer has thus far been to a large extent a reformer; in fact, the very existence of his profession may be directly traced to the prevalence of bad practice in the use of light. The faults of illuminating installations as designed under past conditions at last become so numerous and so obvious, that there arose a demand for reform.... The work of the illuminating engineer thus far has, therefore, been necessarily directed to a large extent toward pointing out the faults of the prevailing practice. Such a course is by no means the most agreeable of tasks, but is a necessary preliminary to better work in the future; and the illuminating engineer must not shrink from this task until the absolute soundness of his contention has been universally recognized.

In most cases the sins of the architect have been rather of omission than commission. With the increasing demands upon his attention from the growing complexity of building, he has given less and less attention to details, and seemingly the least attention of all to the extremely important matter of artificial illumination. Lighting systems have been put in either without the slightest regard to the scientific principles

involved, or at best with the aid of a few rule-of-thumb formulas which were as apt to produce faults as anything else. Only the greater ignorance of the client has prevented an earlier upheaval. Were proportionately serious mistakes made in other points of construction, there is scarcely one building out of ten that would be accepted by the owner when completed. What would one say, for example, on learning that the heating apparatus in his building was wasting 25 per cent. or even 50 per cent. of the fuel? And yet such losses in light are by no means uncommon.

Perhaps from a natural inclination to avoid details, the architect has very frequently delegated his duties to the fixure manufacturer, with the result always to be expected when the blind leads the blind, namely, that they have both fallen. The sins of omission committed by the architect were even surpassed by the sins of commission committed by the fixture maker. Where the architect specified a number of light-sources, figuring in a vague way on the illumination which they would produce if unobstructed, the fixture manufacturer has, perhaps, reduced the illumination to one-half by the accessories and construction used. It is quite to be expected, therefore, that the fixture manufacturer should not welcome the illuminating engineer with open arms. It is bad enough to have one's faults badly pointed out; but when such faults have been an important source of revenue, the sting is so much the keener. There is no denying the fact that a very considerable part of the faults of lighting fixtures are directly traceable to a desire for profit.

....Look at any fixture you please, and judge for yourself how much of the metal work is essential, and how much is a mere excrescence hanging on in the name of art, but having its true motive in the pocket-book. It is the existence of this condition of affairs that has made it necessary for the illuminating engineer to give a greater consideration of the artistic side of their subject than ideal conditions would require or justify, and so long as the condition prevails their efforts must continue....

The principal point in dispute thus far between the illuminating engineer and the architect seems to be a question of jurisdiction. The architect has been comparatively ready to admit the authority of the illuminating engineer in regard to the purely physical and economical aspects of the question, but has denied his authority in matters pertaining to the æsthetic or decorative features involved. The engineer, on the other hand, has contended that under this ruling the architect can practically overthrow the results of his labour by setting up the claim of æsthetic requirements....

Since illuminating engineering involves questions of decorative art, there is no reason why the illuminating engineer should not make a sufficient study of this side of his profession to become an adept. The principles of art as applied to architecture are within the grasp of any intelligent person having a reasonable amount of native appreciation, and there is no more reason why the illuminating engineer should not master these principles, at least, so far as they affect his profession, than there is for the architect not acquiring the general principles of structural engineering.

Whatever his incompetency may be in regard to the purely artistic side of the question, there is one invaluable result that is sure to follow the agitation that has been set up, and that is a greater amount of attention on the part of both professional and layman to the subject of illumination. The results in this regard are already apparent. The very first essential to reform is to discover the need of it, and until this discovery is made and accepted by a sufficient number of the people it is useless to look for improvement. The fact that the former prevailing practice in lighting had numerous and grievous faults is becoming pretty generally known, and as a direct result of this knowledge a demand for better methods is making itself felt.

Papers of Interest before the Illuminating Engineering Society.

Among other papers of special value before the American Illuminating Engineering Society we note those of Dr. H. Seabrook and Mr. Leland Hunter on 'The Effects of Light on the Eye,' and 'Light and Colour in Decoration.' With these papers we mean to deal shortly. Among papers of interest which are to be read before the Society in the course of the next two months we note that of Dr. E. L. Nichols on 'Daylight and Artificial Light.'

The Electric Lighting Installation of a Berlin Theatre.

By Dr. Alfred Gradenwitz.

A great development has taken place in architecture of late years, especially in the art of interior decoration both of dwelling houses and buildings intended for use mainly by night, such as theatres, music-halls, and restaurants. In the latter case, one naturally avails oneself of the recent improvements of electric lighting, so that the artistic features of the interior may show to the best advantage; incandescent lamps have been found well adapted to cases of this nature.

A typical instance of an up-to-date lighting plant of this kind is that of the Neues Schauspielhaus on the Nollendorf Platz, Berlin, which was opened last year. This enormous block, constructed by well-known Berlin architects, comprises, in addition to the theatre proper, a large music-hall (the Mozart Hall), an extensive restaurant, and a manager's office.

The electric lighting installation installed in this extensive set of buildings was designed to meet many special conditions of the case, both from an artistic and decorative standpoint. Also, with a view to the great crowds frequently assembling in these rooms, the risk of danger from fire must be reduced to a minimum.

The installation was designed throughout on the three-wire system, continuous current, at 2×220 volts; the source of supply being the Motzstrasse sub-station of the Municipal Electricity Works of South-Western Berlin. Two distinct special circuits leading to the theatre and terminating at the main switch board are laid from two self-contained feeding points of this sub-station. Each of these circuits in turn comprises two independent sets of mains, allowing the electrical energy to be supplied in four different ways, thus ensuring the greatest degree of safety and reducing the possibility of breakdown, to a minimum, in the event of one cable or other being disabled.

From the main switch-board in the basement below the stage there are feeders leading to four centres of distribution, set apart for the supply of current to the theatre, the Mozart Hall, the restaurant, and manager's office respectively. In connecting the main switching rooms with the feeding points for the theatre and Mozart Hall, a high degree of safety has been secured by providing for two entirely distinct, self-contained, sets of conductors. While only one set leading to the restaurant and manager's building feeding points is in use, the safety of the supply is secured by the arrangement of additional connexions with the general municipal mains, which are situated below the street in the immediate neighbourhood.

Branch conductors are led from the distribution points to the various rooms in each building, the whole system being sub-divided into four main groups corresponding to the four main buildings, which enables inspection and supervision to be easily carried out, and the highest possible convenience in operation. The dimensions and capacity of the lighting-system will be best gauged from the fact that as many as 5,150 incandescent lamps of 16 to 32 normal candle-power and 36 arc lamps for 3 to 20 amp. have been provided, these lamps being distributed over the various buildings in the following manner :—

The theatre and auditorium contain 2,880 incandescent lamps and 2 arc lamps.

The Mozart Hall and accessory rooms contain 590 incandescent lamps and 14 arc lamps.

The restaurant contains 1,210 incandescent lamps and 10 arc lamps.

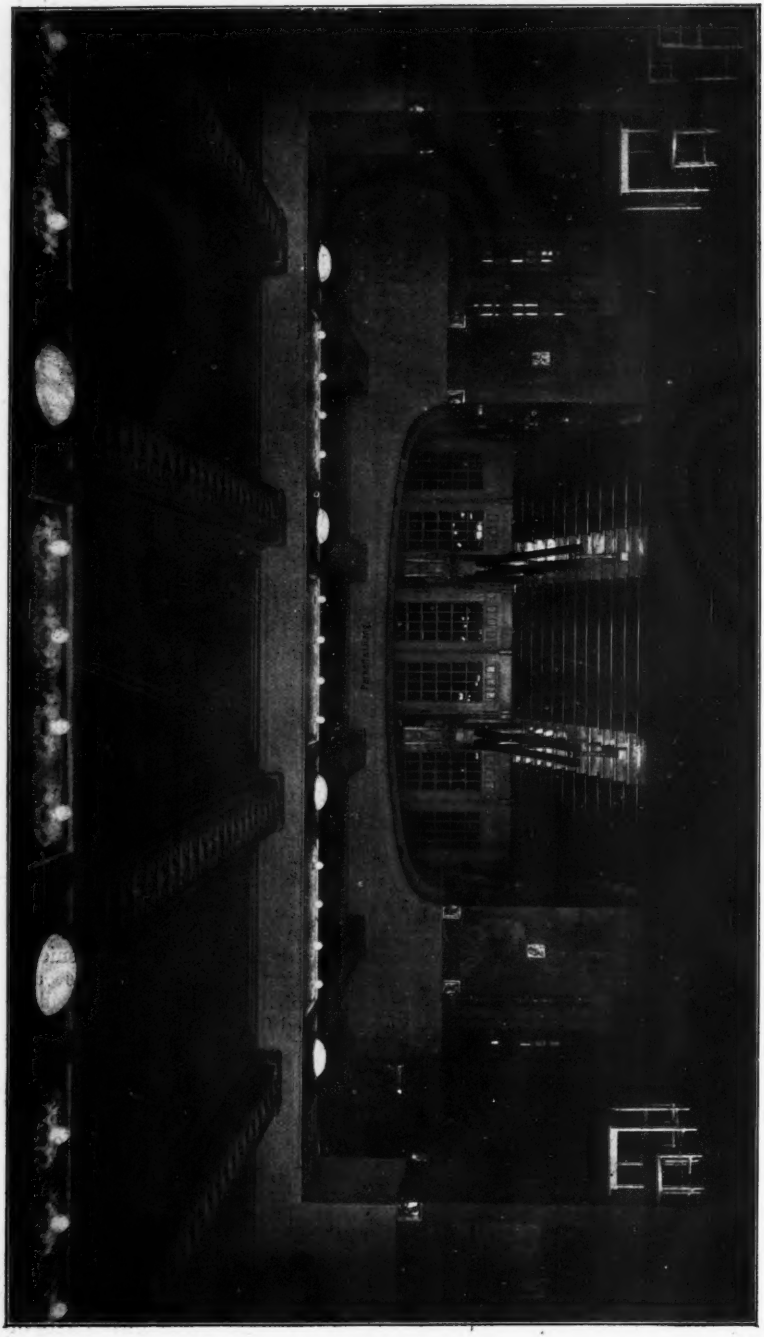


FIG. 1.—Illumination of Main Entrance to Auditorium.

The manager's offices contain 470 incandescent lamps and 10 arc lamps.

In what follows the arrangement of the lamps employed in connexion with the remaining three centres of distribution will, therefore, be dealt with in detail, and also the lighting of the theatre vestibule, in which the distribution of light and general effects of illumination are similar to that occurring in music-halls and modern restaurants.

In order to meet the requirements of interior decoration, every facility had to be given both to the architects and artists in regard to the arrangement of conductors. These had accordingly to be carried, according to their orders, to any point on the walls and ceilings at which any lamps were to be fitted, and yet to be invisible, in order not to interfere with the decorative arrangements. The conductors had also to be permanently accessible in order to facilitate any repair work. These conditions are complied with most satisfactorily by the Peschel steel pipes, which are slashed steel pipes without any inside insulating lining, intended for receiving insulated strand conductors. Instead of cutting threads, as in the case of steel-armoured tubes, and laboriously tightening the muffles as in the case of insulating pipes with inside lining, all that is necessary in this case is to slip the resilient tubes into the smooth muffles and the fittings of the connecting pieces. Owing to the large inside dimensions of the pipes the arrangement and accessibility of the conductors are extremely satisfactory.

The artistic and decorative arrangements are of an extremely varied kind, each of the rooms having a character of its own, to which the electric lighting had to be strictly adapted. Thus the main staircase leading to the first gallery contains chandeliers in which 16 incandescent lamps are mounted together in a polished crystal bowl.

Within the main entrance to the auditorium, the ceiling has been divided into rectangles formed by beams, and over which single lamps are distributed (Fig. 1).

The lobby of the first gallery (Fig. 2) is equipped with exceptionally rich inside decoration. There are two wide entrances equipped with two arcs overhead, situated opposite one another. A number of incandescent lamps are arranged in cavities in the central part of the ceiling, the whole forming an illuminated cupola. The latter in turn is provided with a great number of rosettes, each of which contains an incandescent lamp. Other lighting fittings of more simple design, each carrying 6 incandescent lamps, are used for the illumination of the ceilings of the walks beside the first gallery (Fig. 3).

A combination of incandescent and arc lamps is used for the illumination of the Mozart Hall (Fig. 4). This extends over a length of 29 m. by 16 m. width and 15 m. height, immediately behind the frontage of the main building. To the ceiling are attached 8 arc lamps of 20 amp. and 4 clusters for 44 incandescent lamps each. Below are provided 30 additional lamps of the same kind, giving an average of 200 incandescent lamps used, apart from the 8 large arc lamps for the lighting of this extensive hall.

The incandescent lamps used for lighting this part of the building are exclusively tantalum lamps, of which an aggregate number of 2,000 has been used. The restaurant rooms likewise contain exclusively this type of lamp.

The tantalum lamps are intended for a pressure of 110 volts, being arranged two in series. This arrangement has given excellent results in rooms of this kind, this type of lamp, owing to its brilliant white light and efficiency, having found a wide scope as a competitor to carbon-filament glow lamps.

The large courtyard situated between the buildings has been arranged as a summer garden, and is equipped with 400 tantalum lamps arranged on chandeliers.



FIG. 2.—Illumination of Lobby of First Gallery.

FIG. 3.—Illumination of Passages Adjoining First Gallery.

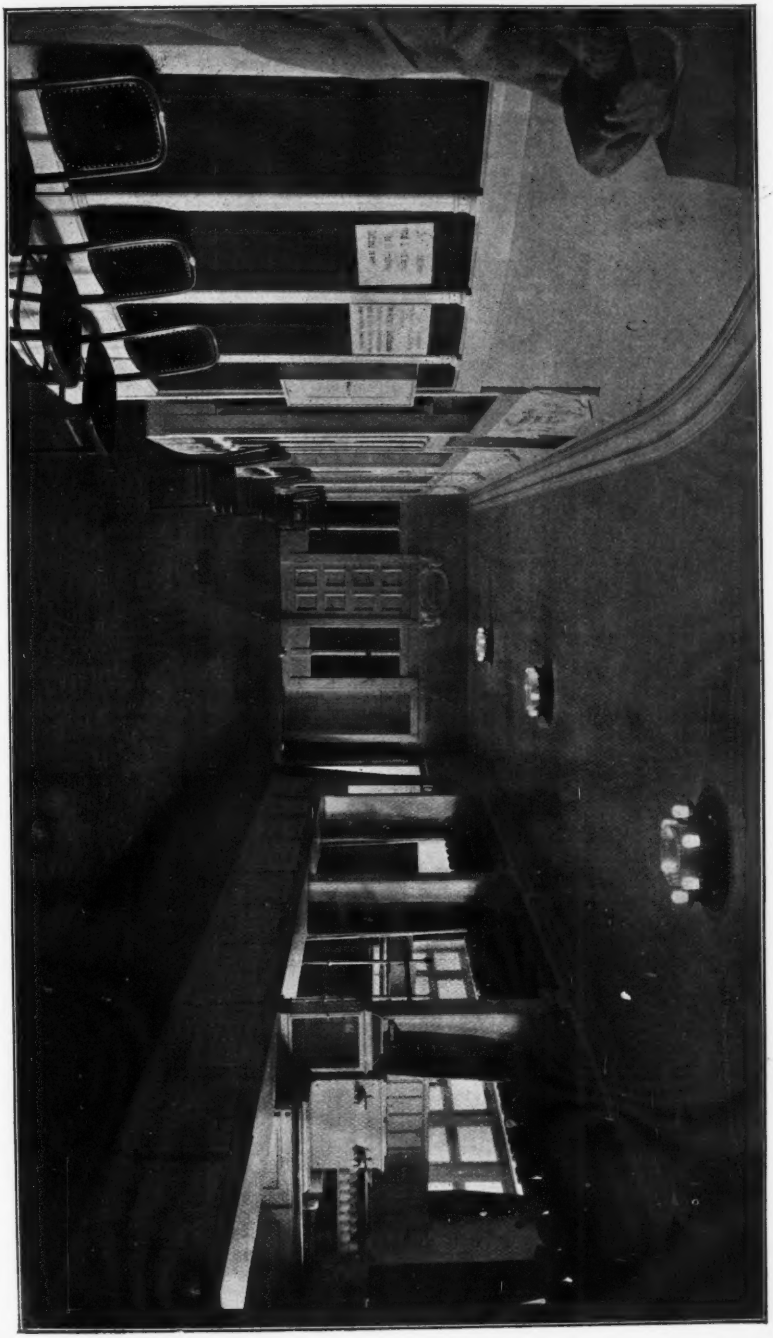


FIG. 3.—Illumination of Passages Adjoining First Gallery.

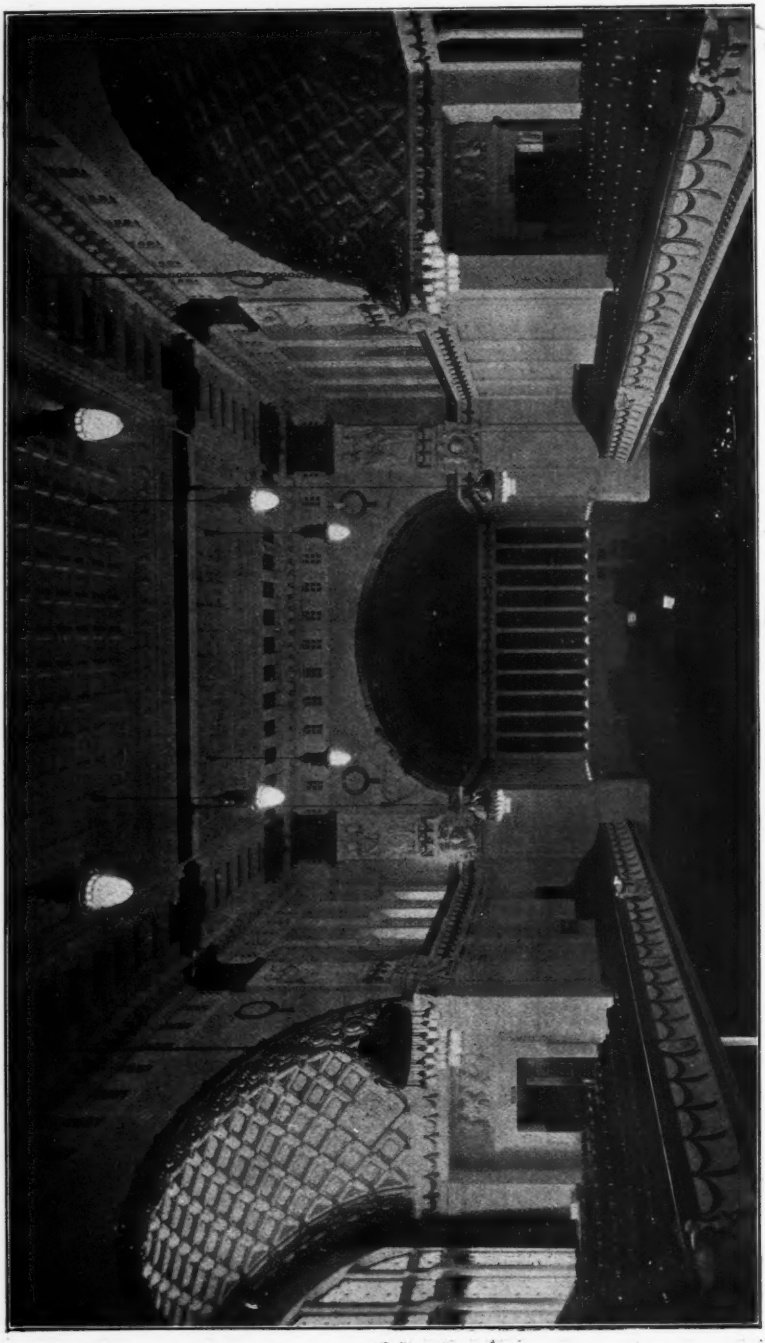


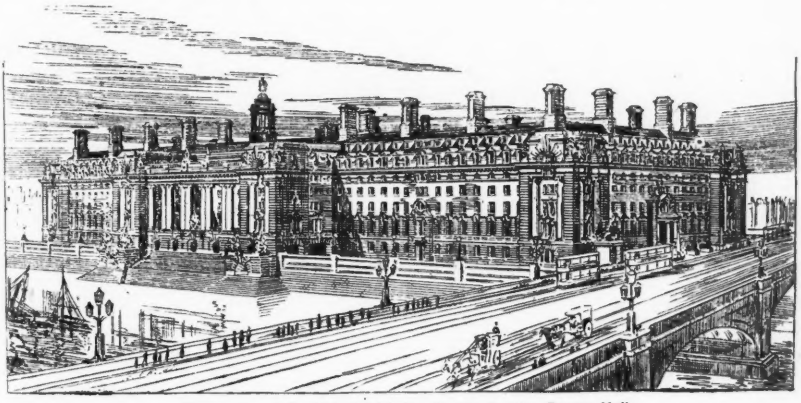
FIG. 4.—Illumination of Mozart Hall.

The Illumination of London's New County Hall.

By a Correspondent.

The municipal building which the London County Council now appears to be seriously contemplating must necessarily form a most interesting topic for discussion and meditation from the point of view of illumination.

As our readers are aware, the design of Mr. Ralph Knott has been selected out of some 150 competing designs sent in from architects practising in all parts of the world. Mr. Knott's ground plan, which was published in a recent number of *The Builder*, scales about 730 ft. long by 240 ft. wide, or covers an area of, say, rather more than four



Perspective of the Selected Design for the London County Hall.
Ralph Knott, *Architect.*

acres. Readers of *The Illuminating Engineer*, who happen to carry in their mind's eye the size of a four-acre field, and are able to imagine such field covered by a building having a ground floor and five floors above this, with a basement, sub-basement, and attics, will be able to form an idea of the magnitude of the proposed building.

The west, or river side, is the more attractive part of the site, and the spacious committee-rooms are arranged along this frontage. Each room is provided with three or four large windows, opening on to the uninterrupted view, so that these rooms will all be well lighted during the daytime. Four large courtyards serve to give light and air access to the rooms situated in the interior of the building. The Council chamber on the first floor and the hall on the ground floor—forming, perhaps, the most striking feature in Mr. Knott's conception—which is to be used as required for public entertainment, are both provided with glazed domes through which (in the absence of fog) ample provision can be made for daylight illumination.

It is in some of the long corridors, particularly those running across the building—a matter of 240 ft.—to which direct rays of daylight can obtain access only through single end windows, that a deficiency is chiefly to be anticipated. This will be more especially the case should these windows, as is more than probable, be devoted primarily to decorative purposes, and to that end be fitted with stained glass, showing some ornamental, allegorical, historical, or figurative sketch, instead of being turned

to the best possible account for the access of the external light. The longitudinal corridors are provided with four windows looking out on each of the four courtyards, and are, therefore, not likely to normally fall below a fair standard of illumination; but the crescent-shaped corridor on the east, or Belvedere Road side will receive only a small share of direct illumination with some addition derived from the main and subsidiary stairways leading to and away from it.

Interesting, however, as these considerations may be, it is rather to the artificial side of the illumination of the building that the attention of readers will turn. Central station engineers, cable manufacturers, manufacturers of switch-boards, fittings, &c., and contractors generally, will be eagerly watching for some indication of what share of the ensuing business—and big business, though still many months far ahead—will fall to their lot. For the electricity supply people there is a fair prospect that high efficiency lamps will be used throughout, unless something yet more efficient shall have made its appearance. By that date the extra efficiency of the metallic filament lamp will have so far leavened the lot of the supply authority that he will be looking back upon 1908 as an age during which it was marvellous that it was possible to make both ends meet on the small load then obtaining, and still more marvellous that it was possible to persuade the poor consumers that they were not being actually robbed by those wicked old black-bulbed carbon lamps.

It is impossible to enter into the maze of calculation which must be put on paper in connexion with a big scheme of this kind before it can be predicted what the annual bill is likely to be, especially under circumstances which will exist in the nebulous future. There are many short cuts, however, whereby an approximate idea may be formed. For example, the chamber in which the Council now meets has a superficial area of about 2,500 square feet, and is illuminated by eleven six-light electroliers and some forty other lamps. These are apparently all tantalum lamps of about 20 candle-power, or, say, a total of 2,120 candle-power. The effect is a soft pleasing light, such as could not be much improved upon in the new building. For the committee-rooms and offices, corridors and basements, store-rooms, &c., such a high rate of lighting would not be desired, as there would be greater facility in bringing the work to the illuminating source, whereas in the Council Chamber the members are frequently obliged to retain one definite position, and hence the light must be ample for all possible positions. Such values, however, as 0·5 candle-power per square foot for the committee-rooms, 0·4 to 0·3 candle-power per square foot for the offices, 0·2 for corridors, basements, &c., with a 10 per cent. margin over all, would indicate that something like 17,000 lamps of 20 candle-power will be required, or the equivalent in inverted arc lamps or other methods of illumination. The annual consumption would be rather more than 200,000 units, or perhaps nearly 250,000 units for lighting only, apart from the energy required by electric radiators, lifts, ventilating fans, &c. Enough has been said to indicate that the illuminating engineer and his satellites will be required, and that there will be room for much display of experience and wisdom in planning this vast scheme.

In conclusion it may be urged that no stone be left unturned to make every detail of the plan and execution, essential to the proper illumination of such a building as this, as perfect as human intelligence can devise.

The Physiological Basis of Illumination.

By Dr. Louis Bell.

(From the *Proceedings* of the American Academy of Arts and Sciences, September, 1907, Vol. XLIII. No. 4.)

The purpose of this paper is to point out that with the existing knowledge of physiological optics artificial illumination can be removed from the domain of empiricism and can be made to rest upon constants which have a definite physiological basis, and which can be, and have been, predetermined with reasonable precision. For obvious reasons data which relate to the sensation of sight cannot rank with exact physical measurements, but they can nevertheless be evaluated closely enough to give a reliable basis of judgment in planning illumination to meet any given requirements.

Except for the aid received from accommodation and in binocular vision from convergence, we see things in virtue of their differences of colour and of luminosity. Of these two the latter is by far the more important, particularly in distant vision. Objects of similar luminosity, but differing considerably in colour, blend into the general view in a most astonishing fashion when at any considerable distance. Objects of similar colour but of different luminosity also fuse into the general field, and if colour and luminosity are both similar, things disappear in a way that is positively amazing. Small coloured areas of moderate luminosity blend even at relatively short range, a fact which the impressionists have turned to extremely good use: albeit they often transfer to canvas the colour vagaries of the tired eye, and the effects of simultaneous contrast rather than the fleeting impressions which they hold so precious. One of Monet's landscapes, however, is wonderfully interesting from the standpoint of physiological optics, and especially in the existence of a critical distance, within which the picture loses its magic.

Practically, therefore, vision depends very largely upon the power of distinguishing differences of luminosity. And since objects in general are luminous only in virtue of light reflected from them, their visibility depends in turn upon their coefficients of reflection. So far, at least, as problems of artificial illumination are concerned, objects seen do not range over a long scale of values of luminosity. Whatever the absolute values of the light reflected, the relative values expressed by the coefficients of reflection range from about 0·80 to about ·01, very few substances returning more than the former or less than ten latter percentage of the incident light.

The fundamental fact at the basis of vision is that the eye can perceive, within a very wide range of absolute intensity, a substantially constant fractional difference of luminosity. This is the purport of Fechner's law, and the fractional difference mentioned is well-known as Fechner's fraction. Its numerical value for normal eyes and ordinary intensities of illumination is from ·02 to ·0055. The importance of this law in practical seeing is enormous, for in a room well lighted by diffuse daylight the illumination may vary from .00 meter-candles down to 10 or 2 in different parts of the room or at different times; and if power of discriminating difference of luminosity changed much with the illumination, one would be purblind most of the time. In some abnormal eyes Fechner's fraction, with vision otherwise normal, is considerably increased, with serious results. A case is cited by Krenchel in which a patient was unable to get about in full daylight without stumbling over things. His condition was most puzzling, until a test showed Fechner's fraction at a value of 0·1. At this value one could not distinguish between dark and light shades of brown and grey, having coefficients of diffuse reflection of, say, ·15 and ·25 respectively, and ordinary shadows on neutral surfaces would therefore disappear entirely. With Fechner's fraction at 0·5 no contrast less than that between white and very dark pigments would be easily distinguished.

Now while Fechner's fraction is fairly constant over a wide range of intensities, one easily realizes that as twilight deepens his power of discriminating shades is seriously impaired. It is this variation of Fechner's fraction with the illumination which determines the minimum amount

of artificial (or natural) light which is effective in enabling one to see things *en masse* in their natural relations. For general vision any illumination above that required to bring Fechner's fraction for the normal eye up to its steady value is needless, and, as we shall presently see, may be injurious.

Human vision, however, is frequently concerned with the observation of fine details both far and near, and the power of seeing these is within wide limits independent of the capacity of the eye for distinguishing small differences of luminosity. In the case mentioned by Krenchel this *visual acuity* was normal, in spite of the extraordinary lack of sensitiveness to variations of light and shade. Acuity seems to depend on the structure of the retina and the quality of the eye as an optical instrument rather than on the direct or secondary sensitiveness of the nerve endings to stimulation and is greatest in the *fovea centralis*, where the cones are most closely packed. The *fovea*, too, is well known to be somewhat less light sensitive than the retina in general. Using a wedge photometer, I find for my own eye that there is a difference somewhat exceeding one stellar magnitude between the foveal visibility and that outside.

Following out this line of investigation, it is not difficult to project the fovea as a dull spot in the field of view. Using a wedge photometer, and fixing the eye at any point on a large sheet of white paper, one finds, on rather quickly cutting down the light by sliding the wedge, a roundish dark spot exactly in the axis, and corresponding in diameter with the projection of the fovea. It is not easy to hold vision of this phenomenon, since the axis of the eye inevitably tends to wander.

By drawing five rather faint crosses

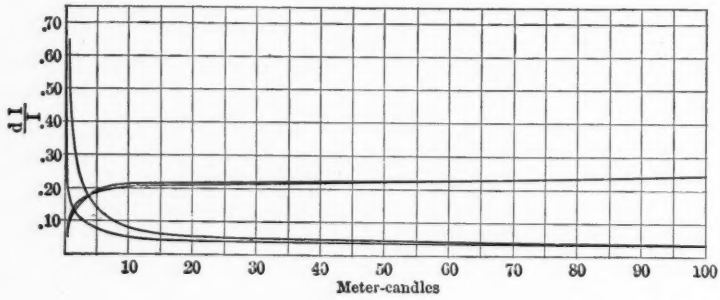


FIGURE 1.

by light. Great acuity is possibly commoner among savage peoples than in civilized races. König * has noted it among the Zulus, whose colour vision, by the way, was normal. It has been found in unusual degree among the Kalmucks, and Johnson† noted it in the Congo peoples, in every case associated with slight hypermetropia. Some observations of Johnson (*loc. cit.*) would suggest that the extremely dark hue of the *fundus oculi*, and consequent diminution of choroidal reflection found among the dark-skinned races, may improve the definition, although, perhaps, at the expense of sensitiveness. It is of course, well known that in the last resort the ability to separate objects like neighbouring points and lines depends on the minute structure of the retina, at the centre and corners of a square, say a decimeter on a side, one can, by careful manipulation of the wedge, make the central cross disappear in the foveal blind spot, while the corner crosses remain visible. The facts regarding the independence and acuity and sensitiveness lend weight to the theory of our confrère Prof. Lowell regarding the bearing of this matter on astronomical observations. Extreme acuity and extreme sensitiveness, being both rather rare, any considerable degree of independence must render the coexistence of both in the same individual unusual in a very much higher degree.

The failure of acuity in a dim light is familiar, and its variation with intensity affords an independent criterion of the necessary requirements in artificial illumination. Enough light must be provided to bring the eye to its normal acuity, as well as to its normal value

* *Nature*, 31, 476.
† *Phil. Trans.*, 191, B. 61.

of Fechner's fraction. Fortunately the researches of Dr. Uhthoff* and of Drs. König and Brodhun † on acuity and Fechner's fraction respectively, give us safe ground on which to travel in these respects.

In Figure 1 are shown the acuity curves and the shade-perception curves of the normal eye for intensities up to 100 meter-candles. Curves *a* and *b* give the values of Fechner's fraction for white light and deep crimson light ($\lambda = 670\mu\mu$) respectively), while *c* and *d* give the acuity curves for light orange ($\lambda = 605\mu\mu$) and yellowish-green ($\lambda = 575\mu\mu$) respectively. The ordinates in the first case are $\frac{dI}{I}$, and in the latter case are in arbitrary units. The most important feature of these curves for the purpose in hand is that they are already becoming asymptotic at low values of the illumination, and except for strong colours at about the same point. At about 10 meter-candles they have turned well towards the axis, and beyond 20 meter-candles the gain in shade-perception and acuity is very slow with further increase. Hence, when the light reaching the eye has risen from 10 to 20 meter-candles, further increase does very little in the way of assisting practical vision.

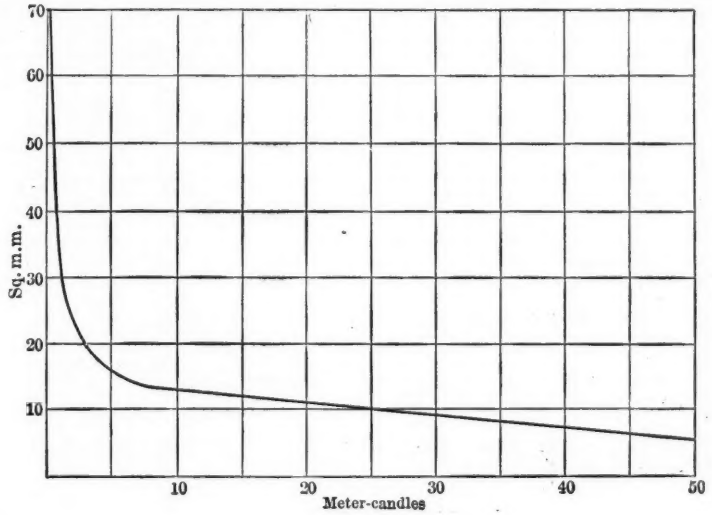


FIGURE 2.

Artificial illumination can be safely based on this amount as a working intensity. Visual acuity is the controlling factor in most indoor lighting. It varies noticeably with colour, but for practical reasons, which will appear later, the actual visibility of coloured objects depends not on the differences here shown so much as upon their general light-reflecting power, which for dark hues is always low.

At great intensities both shade-perception and visual acuity considerably decrease, the former at roughly 25,000 to 50,000 meter-candles, the latter at much lower intensity. Neither function is likely to fail at any intensity reached in the ordinary course of artificial lighting, though acuity may be seriously interfered with by dazzling and consequent rapid retinal exhaustion at intensities of a few hundred meter-candles, and the same secondary cause also impairs shade-perception long before its final decline.

It must be clearly understood that in specifying 10 or 20 meter-candles as the intensity physiologically necessary to bring the eye into its normal working condition, these intensities are those which become visible to the eye, and not merely those that reach the objects under observation.

The light reflected from any object is Ik where I is the incident illumination and k the coefficient of reflection. Then, if a is the normal illumination just indi-

* Graefe's 'Arch.,' 32, 171 ; 36, 33.
† Sitz. Akad., Berlin, 1888.

cated, the required incident illumination is

$$I=\frac{a}{k}.$$

Taking, for example, $a=15$ meter-candles, and assuming that one is observing white or very light coloured backgrounds, for which k would have a mean value in the vicinity of 0·6, the value of I should be about 25 meter-candles. If the background is dark fabric, for which k would not exceed 0.2, I would rise to 75 meter-candles, and for black fabrics one could hardly get too much light. A typical application of the principle may be taken in a draughting-room where tracing has to be done, and the drawing must be well seen through the tracing cloth. k for tracing cloth is about ·35, and the illumination which makes the drawing visible is reflected from the drawing paper behind and passed back through the tracing cloth. The drawing paper probably reflects, if slightly off white, as is common, about 60 per cent. of the incident light, and the final coefficient of the combination falls to about 0·25. Taking the same value of a as before, $I=60$ meter-candles. Ordinary draughting-rooms are found to be well lighted at this intensity. It should be noted that draughtmen generally use hard pencils, which make marks contrasting rather weakly with the paper, so that strong illumination is needed at all times.

In illumination out of doors, as upon the street, where no weak contrasts or fine details need to be made out, a may be taken very much lower, but k is also low, and the minimum of about ·25 or ·30 meter-candle often allowed between lamps is, as the curves show, considerably too small for good seeing.

Effect of Pupillary Aperture.—The iris serves as an automatic stop behind the cornea, adjusting itself so as to protect the retina from too violent changes of brilliancy. It may vary in diameter of aperture from less than 1 mm. up to the full diameter of the visible iris, which in the darkness may retreat even within the rim of the cornea, as Du Bois-Reymond* has shown. The eye therefore works over an aperture range varying from $f20$ or more down to $f2{\cdot}5$ or $f2$. Incidentally the iris, acting as a stop behind the strongly refracting cornea, produces a certain amount of typical "pincushion distortion," which is evident in some optical illusions.

Data on the actual relation between intensity of incident light and pupillary aperture are scarce and imperfect. So much depends on the state of adaptation of the eye, individual sensitiveness, and probably also upon the intrinsic brightness of the source, that reliable values of the relation are difficult to obtain. From a reduction of Lambert's data, however, I have plotted the curve of Fig. 2, giving as abscissæ the illumination in meter-candles, and as ordinates the area of the pupil in square millimeters. The striking fact is at once in evidence that this curve, like those of Fig. 1, is rapidly becoming asymptotic in the neighbourhood of 10 meter-candles. In other words, the contraction and expansion of the iris is less to protect the eye at high intensities than to strengthen the retinal image at low intensities, even at the expense of considerably impaired definition.

* 'Centralbl. f. prakt. Augenheilkunde,' 1888.

(To be continued.)

Incandescent Gas Lighting.

A Word of Caution.

Mr. Thomas Newbigging read a short paper under the above title at the recent meeting of the Manchester District Institution of Gas Engineers.

He drew attention to the fact that, in spite of the value of the incandescent mantle to the gas industry, it had, for various reasons, not yet been adopted by the majority of consumers. Therefore it seemed premature to begin already to devote attention solely to the needs of the incandescent mantle, and, in consequence, immediately produce gas of lower illuminating power.

Moreover, in order to secure the most perfect results in incandescence-lighting, an increase in pressure beyond that utilized for flat-flame burners was necessary. If this point did not receive adequate attention, the consumer would inevitably be disappointed, and raise the cry of "bad gas."

The day might come when a non-illuminating gas and illumination by incandescence would become universal. But that day had not dawned yet, and any premature effort to force the adoption to these conditions might prove unfortunate for the gas industry.

The Gas World, March 7th, 1908.

Inverted Gas Lighting.

By M. C. Whitaker.

(From the *Transactions* of the Illuminating Engineering Society, Dec., 1907.)

The most important step in the improvement of illuminating devices embodying the use of the Welsbach mantle is now being made in the commercial introduction of the inverted incandescent gas lamp. Large numbers and varieties of these lamps have appeared in the American market within the last few years, and the activity shown by manufacturers and promoters of this type of lighting device must naturally suggest to the minds of those interested in gas lighting that there are some basic reasons for this development.

It is the purpose of this paper to indicate these reasons and to review the problems encountered in the development and introduction of this system of lighting. Its commercial outlook is exceedingly promising, and it behoves those interested in the use of gas illumination to familiarize themselves with the problems involved and the present trend of developments.

The primary reasons which tend to explain the interest in the inverted incandescent gas lamp may be indicated as follows:—

1. Improved efficiency and economy.
2. Better direct downward distribution of the light.
3. Superior decorative possibilities.
4. Greater durability and longer candle-power life of the mantle.
5. Units naturally adapting themselves to all conditions and uses.

In addition to these primary reasons, many minor advantages may be cited which place the inverted gas lamp on the highest plane for economical general illumination.

The accompanying tables will serve to show the comparative cost of operating the various lighting systems now in

TABLE I.

GAS.

LIGHT.	Rate per M. Cu. Ft.	Cu. Ft. per Hr.	Mean S. C. P. of Unit.	Cost per Hour of Unit.	Quantity for 1c.		REFERENCES.
					Cons.	M.S.C.P.	
Acetylene Gas ...	$15.00	·5	12·7	$·0075	¢·66	16·9	Average of 20 towns. Brown's Directory, 1907. Practical Illumination, p. 97.
Open Tip Burner	1.00	5·0	21·0	·005	10·	42·0	Practical Illumination, p. 79.
Gas Arc Clear Globe... ...	1 00	18·8	228·7	·0188	10·	121·6	Welsbach Testing Laboratory.
Upright Mantle, Clear Chimney	1.00	3·7	63·0	·0037	10·	170·0	Practical Illumination, p. 82.
Inverted Mantle, Clear Chimney	1.00	3·0	54·0	·003	10·	180·0	Practical Illumination, p. 90.

TABLE I.—*Continued.*

ELECTRICITY.

LIGHT.	Rate per Kilo Watt.	Watts per Hr.	Mean S. C. P. of Unit.	Cost per Hour of Unit.	Quantity for 1c.		REFERENCES.
					Cons.	M.S.C.P.	
Cooper Hewitt...	$.10	192	238·96	$·0192	100	124·4	Illuminating Engineer, Vol. I., p. 449.
Enclosed Arc ...	.10	600	213·0	·060	100	35·5	Practical Illumination, p. 121.
Gem, Clear Bulb	.10	125	40·7	·0125	100	32·56	Practical Illumination, p. 42.
Nernst, Clear Globe, 3-glower	.10	264	81·0	·0264	100	30·7	Practical Illumination, p. 115.
16 C. P. Edison	.10	55	13·2	·0055	100	24·0	Practical Illumination, p. 26.

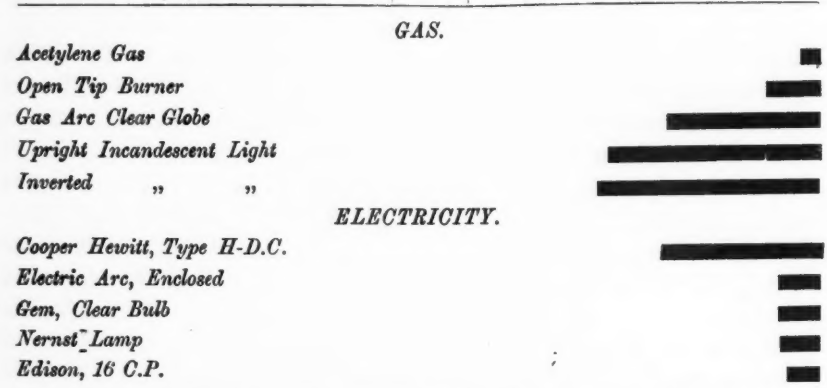


DIAGRAM SHOWING COMPARATIVE AMOUNTS OF CANDLE-POWER HOURS OBTAINED FOR ONE CENT; SPHERICAL READINGS.

common use for indoor illumination. The candle-power and consumption figures quoted in these tables are taken from actual tests made by expert observers and quoted from standard authorities. The rates are based upon the average quoted prices in our largest cities.

The full meaning of the figures given in the table may be made clearer by reference to the diagram, which represents the comparative amount of candle-power obtained for 1 cent. cost for the different systems of lighting.

Table I. is based upon the mean spherical candle-power obtained by taking the average of the candle-power readings at points ten degrees apart in a vertical plane through the centre of illumination. (See Fig. 1.) This comparison shows a larger candle-power yield per unit of cost for the inverted incandescent gas lamp; but calculations based upon the spherical candle-power are very misleading, and a further study of the direction of distribution is interesting.

Inasmuch as the source of illumination in the standard installations is usually overhead, it is apparent that the light distributed above the horizontal plane through the source is largely wasted,

unless some medium of reflection be installed to divert the light into the lower portion of the room. It, therefore, follows that a source of light which gives its main distribution below the horizontal plane, without the necessity of using a reflector, occupies a position of great advantage and economy.

serve the purpose for which they are intended without loss. It seems fair, therefore, in considering the value of a source of light for illuminating purposes, that the factor of lower hemispherical candle-power, rather than the total spherical candle-power, should be regarded as of principal importance.

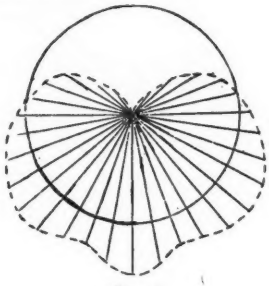


FIG. 1.



FIG. 2.

Where the greater percentage of direct light falls above the horizontal plane it is necessary to use reflectors to divert it into the lower portion of the room. Its reflection cannot be accomplished without a certain loss—this loss depending entirely upon the efficiency of the reflecting medium. On the other hand, the direct rays of light naturally distributed in the field below the horizontal plane

Table II., with its accompanying diagrams, shows the comparative amount of light obtained for 1 cent., based on readings of the lower hemispherical candle-power. (See Fig. 2.) The tests are based upon burner equipments without any reflecting glassware, it being assumed that a reflector can be used with equally effective results in any or all of the cases cited.

TABLE II.

GAS.

LIGHT.	Rate per M. Cu. Ft.	Cu. Ft. per Hr.	Mean L. H. C. P. of Unit.	Cost per Hour of Unit.	Quantity for 1c.		REFERENCES.
					Cons.	M.L.H.C.P.	
Acetylene Gas ...	$15.00	·5	11·6	$·0075	6·66	15·5	Average of 20 towns. Brown's Directory, 1907. Practical Illumination, p. 97.
Open Tip Burner	1.00	5·0	20·0	·005	10·	40·0	Practical Illumination, p. 79.
Gas Arc, Clear Globe ...	.100	18·7	244·0	·0188	10·	129·8	Welsbach Testing Laboratory.
Upright Mantle, Clear Chimney	.100	3·7	51·27	·0037	10·	138·5	Practical Illumination, p. 82.
Inverted Mantle, Clear Chimney	.100	3·0	70·6	·003	10·	235·33	Practical Illumination p. 90.

TABLE II.—*Continued.*

ELECTRICITY.

LIGHT.	Rate per per Kilo Watt.	Watts per Hr.	Mean L. H. C. P. of Unit.	Cost per Hour of Unit.	Quantity for 1c.		REFERENCES.
					Cons.	M.L.H.C.P.	
Cooper Hewitt ...	$.10	192	238·96	$·0192	100	124·4	Illuminating Engineer, Vol. I., p. 449.
Enclosed Arc ...	.10	600	329·05	·060	100	54 84	Practical Illumination, p. 121.
Gem, Clear Bulb	.10	125	36·96	·0125	100	29·56	Practical Illumination, p. 42.
Nernst, Clear Globe, 3-glower	.10	264	144·26	·0264	100	54·6	Practical Illumination, p. 115.
16 C. P. Edison	.10	55	11·68	·0055	100	21·78	Practical Illumination, p. 26.

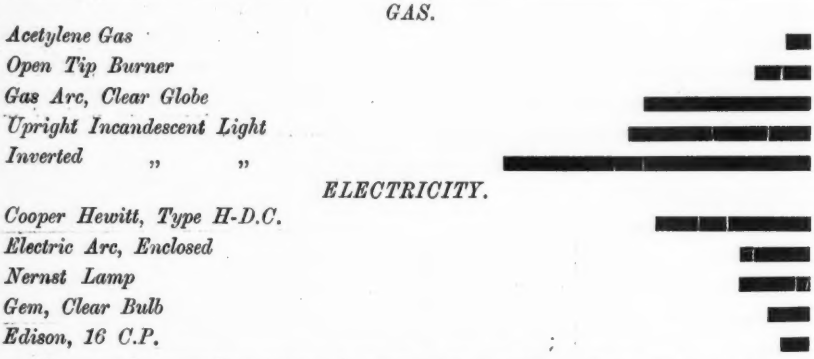


DIAGRAM SHOWING COMPARATIVE AMOUNTS OF CANDLE-POWER HOURS OBTAINED FOR ONE CENT; LOWER HEMISPHERICAL READINGS.

It will be noted from Table II. that an enormous advantage obtains in favour of the inverted incandescent gas lamp. Considering the various lighting systems now in use with special reference to production of illumination at minimum cost this advantage is so pronounced that it cannot be overlooked. This fact alone offers a very convincing reason for the prevailing interest and activity in the development and application of the inverted system of incandescent gas lighting.

The inverted gas lamp combines useful illumination with artistic and decorative effects not attainable in any other system. The lighting unit is of such a size that its direct downward distribution meets the requirements of ordinary illumination while the light distributed in the upper hemisphere is available for utilization in producing beautiful and decorative colour effects with various designs of globes and shades. Chandeliers, brackets, pendants, and dining-room fixtures, especially designed in both metal and glass equipment, have been provided in infinite variety to meet the favourable decorative possibilities offered by inverted lamps.

The inverted gas lamp naturally gives a free downward distribution of light,

with a resultant illuminating effect which cannot be obtained by the upright incandescent system, from the fact that the greater portion of the candle-power yield of the upright burner is in the upper hemisphere, thus necessitating the use of reflecting shades more or less inefficient in operation. Moreover, notwithstanding the use of these reflectors, it is not possible to overcome entirely the loss due to shadows caused by interposition of the metal parts of the burner, chandelier, &c., directly in the path of the downward distribution of the light.

The inverted lamp has no structural parts interposed in the path of illumination; without the use of reflectors, it gives the greater percentage of its candle-power distribution directly into the portion of the room which requires illumination; and from these essential features it follows that by the use of special reflectors, designed for concentrating and directing the rays of light, results embodying unusually high economy may be obtained.

Mantle renewals of the inverted lamp must be considered a factor in estimating the cost of operation. Whether or not this is a greater factor than the various renewal items entering into the maintenance of the other forms of illuminating devices does not appear from any figures available. The experience so far obtained is that renewal cost for mantles for the inverted lamp is very materially less than for the upright burner. The construction and size of the mantle is such as to give it a greater physical strength.

Several designs of mantles are now in use, and, unfortunately, there are several standard fittings for attaching these mantles to the burner. The best quality mantles are mounted on magnesia rings with projecting fingers to hold the mantle in position on the burner. Metal rings have been used to some extent, but have not proved desirable on account of the corrosive action of the flame.

A lighting unit furnishing from 50 to 100 candle-power is found by experience to be better suited for general use than the smaller units, as furnished by individual incandescent electric lamps, or the larger units, as furnished by arc lamps. In gas lighting the demand for larger units is met by cluster lamps, but for lighting machines, office desks, reading tables, residences, &c., a unit of less than 50 candle-power would not be sufficient to meet general requirements.

The development of the inverted incandescent gas lamp divides itself into two distinct epochs.

The first inverted incandescent lamps were made by Clamond and exhibited in 1882–3 at the Crystal Palace Exposition in Paris. Considerable activity was subsequently shown by inventors, and numerous forms were exploited without commercial success. This was prior to the successful development of the thorium-cerium mantle by Dr. Auer, and the incandescing devices used in these early lamps were in the form of magnesia baskets, platinum cones, &c. Furthermore, the burners used in these demonstrations were successful only when compressed air or compressed gas, or both, were utilized. Their construction at that time did not overcome the problem of producing combustion with the burner inverted, except by the use of an abnormal pressure. With the advent of the Welsbach upright mantle, this line of research was abandoned, and no developments of any consequence were made for eight years.

The interest in the inverted incandescent gas light was renewed by the development of a burner for the utilization of a thorium-cerium mantle, which was shown abroad about 1900. These inverted lamps did not meet with marked commercial application in this country, because their designers failed to take into account the principles which modern inverted burner builders recognize as basic.

The early burners served, however, to acquaint illuminating engineers with the many points of superiority to be obtained by the use of the inverted light, and experimental activity was greatly increased, with a view to overcoming the many difficult problems in design, construction, and operation in this type of lamp.

(To be continued.)

The Luminous Properties of Conducting Helium.

By P. G. Nutting.

(Bull. Bureau of Standards, abstracted *Elec. World*, Feb. 22, 1908.)

The author describes some experiments having for their object the testing of the qualities of luminescent helium gas as a standard of light. Luminescent gases represent extremely efficient sources of light, and attention has recently been drawn to the possibility of reproducing the exact conditions under which such a gas yields a certain definite candle-power very closely, and hence also the possibility of producing a standard of light by this means.

Conducting helium emits a yellowish-white light, which is very convenient for photometric comparisons with glow-lamps. Carbon dioxide yields a much whiter light, but decomposes and disappears very rapidly, even with moderate current-densities.

In this connexion it is interesting to observe that Mr. Moore recently advocated the use of the carbon-dioxide Moore tube, as a standard, both on the grounds of its being easily reproduceable, and yielding a spectrum closely resembling that of daylight. (See Discussion of paper by C. E. Stickney, reprinted in The Illuminating Engineer for February, p. 161.)

Sulphur vapour emits a bluish-white light, but its density is difficult to measure and control. Helium, however, is easily controlled, and has the advantage of not becoming decomposed and disappearing rapidly, as the other gases do when carrying a relatively heavy current. Thus the life of a helium tube is about fifty hours, as compared with half an hour on the part of similar tubes filled with hydrogen and nitrogen.

The author next proceeds to describe the precautions which are needful in preparing tubes of helium for standard purposes. Naturally a mercury pump cannot be used for the purpose of exhausting the tube, on account of contamination by mercury vapour, and special measures are necessary to get rid of all traces of hydrogen and other impurities. The tubes utilized have been about 1-3 mm. in diameter and 10-50 mm. long, and were supplied with current from a 5,000 volt transformer. The intensity of the light produced was compared with that of a small 4 volt glow-lamp, by means of Lummer-Brodhun photometer, and the probable errors of observation are estimated at under 1 per cent.

The general nature of the variation in candle-power of the tube with current is shown in Fig. 1, while the corresponding fall in potential is shown in Fig. 2. In this connexion it may be mentioned

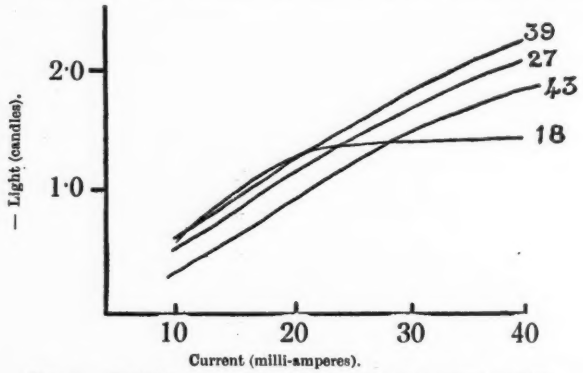


Fig. 1.—Variation of Light with Current in Different Tubes.

that a variation of 5-10 per cent. in the fall of P.D. could be produced by directing a flame or blast of cold air on the tube: the diminution, however, did not cause a corresponding change in the light emitted, as long as the current was kept constant.

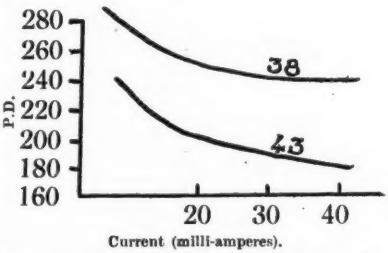


FIG. 2.—Variation of P.D. with Current in Different Tubes.

The luminous efficiency of helium is a maximum for a current density of about 6 milli-amperes per square millimetre; it is, in any case, exceptionally low for a gas, owing to the presence of three strong infra-red lines in the spectrum at 728, 1,117, and 2,040 $\mu\mu$, representing, at least, 90 per cent. of the total energy, and yet adding nothing to the luminous output of the gas.

The effect of gaseous-pressure upon the light from the tube is shown in Fig. 3. It will be seen that in the case of the 2 millimetre tube, the light is very slightly affected by a wide range of pressure.

Reference may also be made to the possible influence on the light of the tube of the variety of current utilized. The results of some experiments on this point are shown in the table below.

It is very interesting to observe that the light seems to vary only with the current, and to be practically independent of the nature of the discharge.

The effect of another factor influencing the result, namely, the bore of the tube, is shown below.

It will be seen that the relation between diameter of tube and light emitted is practically a linear one, as was found to be approximately the case for the other important influential factor, the current (see Fig. 1).

In order to test the possibility of reproducing tubes giving as near as possible exactly the same candle-power, a set of six duplicate tubes were prepared. As a result the greatest deviation from the mean was only 1 per cent., while the average is probably under $\frac{1}{2}$ per cent.

Many other tests were carried out with a view to testing the reproducability of the standard. Thus, after a long series of experiments with varying currents and positions of the tube, the initial conditions would be restored, and in every case identical results were obtained. In a few instances an apparent discrepancy was observed, but this invariably proved to be due to some obvious defect, such as a crack in the glass, &c.

These experiments may therefore be said to be distinctly favourable to the use of the helium tube as a standard.

EFFECT ON LIGHT EMITTED OF CHANGING THE NATURE OF THE CURRENT.

Nature of Current.	Light Emitted.	
	22·5 milli-amperes.	23·7 milli-amperes.
Direct, 1,000 volts	1·21	1·30
Alt., 60 cycles, 2,000 volts ...	1·22	1·28
„ 60 „ , 5,000 „ ...	1·22	1·29
„ 900 „ , 5,000 „ ...	1·21	1·29

EFFECT OF BORE OF TUBE ON LIGHT EMITTED.

Diameter of Tube mm.	1·029	1·949	2·168	3·120
M.H.C.P., per cm. of tube at 25 milli-amperes	0·365	0·325	0·311	0·259

In this connexion the three chief points requiring further investigation are :—

1. Differences between separate determinations of the same observer on the same tube. These are probably not serious, and of the same order as uncertainties occurring in ordinary work.

2. Uncertainties due to using different tubes. Reproducability will require further investigation with tubes of different diameter and composed of different kinds of glass. Experiments so far suggest that this uncertainty will not be serious.

3. Uncertainties due to varying the observer, on account of colour-difficulties. These are, perhaps, the most serious, and will require careful study by many different observers.

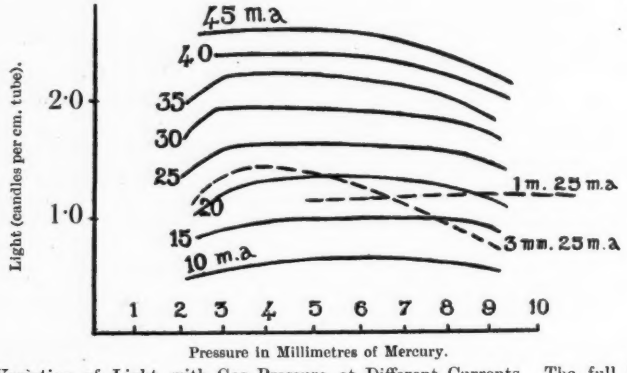


FIG. 3.—Variation of Light with Gas Pressure at Different Currents. The full line curves refer to a 2 mm. tube.

The Metallic Filament Lamps and the Arc Lamp.

The Electrical World has recently remarked upon one especially interesting aspect of the metallic lamp situation, which has doubtless also occurred to many of those connected with the electric lighting industry.

It seems likely that the usefulness of the ordinary carbon arc lamp will be considerably reduced by the advent of metallic filament lamps of high candle-power, running at an efficiency of only 1 watt per candle-power. The arc lamp has previously found favour partly on account of its high efficiency, but also on account of its value in cases where a high candle-power is desirable. Previous to the introduction of metallic filament lamps, the necessity for some source of light intermediate between the arc lamp and the ordinary carbon filament glow-lamp had led to the design of miniature arc lamps of various patterns ; but with the advent of the metallic filament lamp the necessity for such lamps may be said to have very greatly diminished, except in cases where a very high concentrated candle-power is essential, and where a very large area is to be illuminated. Under these conditions the great bril liancy and efficiency of the flame lamp may enable it to hold its own. We gather, however, from *The Electrical World* that the flame arc has not come into very general use for street illumination in the United States, its use being chiefly restricted to purposes of advertisement, bill-board illumination, and so forth.

REVIEWS OF BOOKS.

DIE BELEUCHTUNGSARTEN DER GEGENWART.

By Dr. W. Brüsch.

(*B. G. Teubner, Leipzig.*)

This little book deals briefly with all kinds of illuminants, gas, electricity, oil, acetylene, &c., in a popular manner. In the 161 small pages at his disposal the author is naturally constrained to treat the subject in a very condensed manner, but, nevertheless, manages to impart a considerable amount of useful information, which will doubtless be of value to those requiring a brief summary of the subject. He, however, confines himself mainly to the actual processes and apparatus for the production of light without attempting to enter deeply into its utilization. Thus the book deals with illuminants rather than illumination, though the first chapter touches upon the principles of light-measurement.

The author is aided in his task by a liberal use of illustrations.

DIE ELEKTRISCHEN KOHLEN-FÄDENLAMPEN, IHRE HERSTELLUNG UND PRUFUNG.

By Heinrich Weber.

(*Max Janecke, Hannover, Germany.*)

Though the author of this book deals mainly with the carbon filament lamps, much of the information conveyed therein is of general application to lamp-manufacture, and will be read with interest at the present time, when the properties of metallic filament glow lamps have come to be regarded as of paramount importance.

He traces the gradual development of the entire lamp, and describes many processes, the details of which have hitherto not been generally known, the text being accompanied by many excellent photographs and illustrations.

There is no doubt that Dr. Weber's practical acquaintance with the subject enables him to deal with the matter with unusual explicitness, and we feel sure that his book will be found of value by those interested in glow-lamp manufacture.

THE MODERN GLOW-LAMPS FROM THE CONTRACTOR'S STANDPOINT.

At a meeting of the London section of the Contractors' Association, held at Frascati's Restaurant on Friday, March 12th, Mr. Leon Gaster dealt with the new metallic and other glow-lamps from the contractor's point of view. He referred to the value of standard specification for making of glow-lamps in enabling the contractor to readily recognize those which were not satisfactory. He also described the recent progress in the manufacture of metallic filament lamps and their advantages and drawbacks, urging the contractor to exercise caution in considering the exact circumstances under which they were of value, and to refrain from recommending them indiscriminately.

The exceptionally full attendance at this meeting and the discussion which followed, showed that contractors are fully alive to the importance of the subject.

THE REPORT OF THE NATIONAL PHYSICAL LABORATORY.

The report of the National Physical Laboratory for the past year has now been issued. During the last year a number of investigations, designed to trace the small variations existing between different pentane lamps, were carried out. Many tests on glow lamps were also undertaken in co-operation with the Engineering Standards Committee.

In July Mr. Patterson represented the Laboratory at the International Photometrical Commission at Zürich. As a result of the meeting of the Commission the important relations existing between the Hefner, the Vernon-Harcourt, and the Carcel standards of light were definitely determined.

It is now proposed to establish a set of sub-standards intended for use in testing metallic filament lamps, which will be run at 2·8 and 2 watts per candle. It is also hoped that investigations into the Violle standard will be carried out in accordance with the recommendation of the International Commission.

CORRESPONDENCE.

International Photometrical Nomenclature.

SEHR VEREHTER HERR GASTER,—Die Ausfuhrungen von Herrn Laporte auf Seite 253 sind insofern ein wertvoller Beitrag zu meiner Arbeit über 'Die Unzuträglichkeit der gegenwärtigen internationalen Bezeichungsweise fur Beleuchtungswerte,' als sie gezeigt haben, dass es heute ein französisches Lux und ein deutsches Lux gibt. Es gab auch, wie ich erwähnte, ein englisches Lux, das von Preece, das aber ganz aus dem Gebrauch gekommen ist. Meine Anregungen, die Einheit der Beleuchtung auf eine Internationale Basis zu erheben sind also um so notwendiger geworden.

Die strikte Befolgung der Beschlüsse des Genfes Kongresses von 1896 liess nicht direkt, wie Herr Laporte es angibt, ein französisches und ein deutsches Lux entstehen. Denn damals im Jahr 1896 war als Name der Lichteinheit zwar die bougie decimale (definiert als $\frac{1}{20}$ Violle) angenommen worden, da "bougie decimale" jedoch nur ein Wort und keine reelle Lichtquelle ist, war in Genf 1896 beschlossen worden, die bougie decimale "vorlaufig praktisch durch die Hefner-lampe darzustellen." Man war nach dem Stande der Messungen von 1896 Beziehung ausgegangen, dass die Lichtstärke der bougie decimale und die der Hefnerlampe auf 2 % ubereinstimmen (1 H.K. = 1,02 bougies dec.), eine für die praktische Photometrie gewiss genügende Genauigheit.

Erst später war es Herr Laporte, der nachwies, auf Grund der neugefundenen Beziehung :—

1 Carcel = 10,9 H.K.

und der früheren als feststehend von Violle ubernommenen Beziehung :—

1 Carcel = 9,6 bougies dec.

dass ein Hefnerkerze nicht mehr gleich 1,02 bougies dec. ist, sondern dass :—

1 H.K. = 0,885 bougie dec. also eine Abweichung von 11,5 % gegen früher.

DEAR MR. GASTER,—The remarks of M. Laporte on page 253 constitute a valuable addition to my article on 'The Incongruities of the Present International System of Denoting Values of Intensity of Illumination,' in so far as they make it clear that today both a French and German Lux exist.

At one time, as I mentioned, there was also an English Lux—that suggested by Mr. Preece (now Sir W. Preece, —but this term has fallen completely into disuse.

The establishment of the unit of intensity of illumination on an international basis, which I have advocated, is therefore all the more essential.

But the simultaneous existence of a French and German Lux is not, as M. Laporte suggests, a direct consequence of the decisions of the Geneva Congress of 1896. In that year the "Bougie decimale" (defined as $\frac{1}{20}$ of the violle) was indeed adopted as the name of a unit of light, but as this term only represented a value and not an actual source of light, it was also decided "that a bougie decimale" should "meantime be defined practically in terms of the Hefner lamp."

Owing to the state of photometrical measurements in 1896, people were under the impression that the intensity of the bougie decimale and the Hefner lamp agreed within 2 % (1 H.K. = 1·02 bougies decimales)—an exactitude which certainly suffices in practical photometry.

It was only afterwards that M. Laporte pointed out that, on the basis of the newly determined relation :—

1 Carcel = 10·9 H.K.

and the relation previously adopted as derived from the Violle standard :—

1 Carcel = 9·6 bougies decimales,

one Hefnerkerze could no longer be assumed to be 1·02 bougies, but that

Nachdem nun durch die Internationale Lichtmesskommission im Juli 1907 festgesetzt worden war, dass fernerhin 1 carcel nicht mehr 10,9 H.K. sondern nur 10,75 H.K. ist, ergibt sich der Wert,

1 H.K. = 0,895 bougies dec. der heute gültige Wert, den Herr Laporte auch auf Seite 254 angibt.

Der Entwicklungsgang des französischen und deutschen Lux ist also der, dass beide im Jahre 1896 zur Zeit der Genfer Beschlüsse praktisch gleich sind.

1896 1 deutsches Lux = 1,02 Französisches Lux (Fehler 2 %).

1907 1 deutsches Lux = 0,895 Französisches Lux (Fehler 10,5 %).

In dem letzten Absatz des Briefes von Herrn Laporte auf Seite 254 möchte ich bemerken, dass die praktische Gleichheit der bougie decimale, der 1 Kerzen Pentanlampe, und der spermaceti candle für die Beleuchtungsmessungen, auf die sich lediglich meine Ausfuhrungen bezogen, nicht so sehr eine " glücklicher Vereinfachung in jeder Hinsicht " bedeuten, so lange England und Amerika in die Beleuchtungsberechnungen nicht das meter, sondern den foot einfuhren. Und die Angaben in " candle-feet " oder " foot-candles " sind in englischen Arbeiten uberwiegend.

Mit vorzüglicher Hochachtung Ihr sehr ergebener,

DR. BERTHOLD MONASCH,

Oberingenieur der allgemeinen Elektrizitäts Gesellschaft, Berlin.

1 H.K. = 0·885 bougie dec., *i.e.*, a deviation of 11·5 % as compared with the former value.

After the decision of the International Photometrical Commission of July, 1907, that 1 Carcel must be taken not as 10.7, but as 10·75 H.K., this relation becomes—

1 H.K. = 0·895 bougie dec., the value which must be regarded as correct at the present time, and which M. Laporte quotes on page 254.

The development of the French and German values of the Lux thus arose from the fact that in 1896, at the time of the Geneva Congress, the two were regarded as practically identical.

In 1896 1 German Lux = 1·02 French Lux (Error 2 %).

In 1907 1 German Lux = 0·895 French Lux (Error 10·5 %).

With reference to the last paragraph in M. Laporte's letter on page 254, it may be remarked that the practical equality of the bougie decimale, the 1 c.-p. (Pentane lamp), and the spermaceti candle, on which my whole contentions are based, cannot be regarded as a " fortunate simplification in every respect " as long as England and America continue to use the foot and not the metre in measurements of illumination; such expressions as " candle-feet " and " foot-candles " certainly predominate in English literature on the subject. I am,

Yours very sincerely,

DR. BERTHOLD MONASCH,

Chief Engineer of the General Electric Company, Berlin.

The Thermopile in Practical Photometry.

SEHR GEEHRTER HERR,—Für das gefl. Schreiben vom 6. d. M. so wie für die liebenswürdige Ubersendung des 3ten Heftes des *Illuminating Engineer* sage ich Ihnen meinen besten Dank.

Ihre Bemerkungen zur meiner Arbeit auf S. 179 habe ich mit grossem Interesse gelesen und stimme Ihnen darin vollkommen bei, dass bei der Verwendung der Thermosaule zur photometrischen Zwecken ein gewisses Mass von optischen und strahlungs-

DEAR SIR,—I beg to thank you for your letter of March 6th, and also for kindly sending me the third number of *The Illuminating Engineer*.

I have read with interest your remarks on my work on p. 179, and quite agree that, when applying the thermopile to photometrical purposes, a certain knowledge of optics and the theory of radiation is necessary; but I also believe that this is particularly desirable in the case of the photometry of arc lamps.

theoretischen Kenntnissen vorhanden sein muss, glaube aber dass man dies bei der Photometrie von Bogenlampen um vor allen Umstanden verlangen muss.

Für übrigen ist wohl zu unterscheiden zwischen der Anwendung meiner Methode bei el. Glühlampen, Gasglühlicht, und ähnlichen auf der einem und bei Bogenlampen insbesonders Flammenbogenlampen auf der anderen Seite. Bei el. Glühlampen muss die Untersuchung mit der Thermosaule immer richtige Resultate geben, wenn man nur den Abstand von Thermosaule und Lampe gross genug wählt. Und dies kann man immer, weil hier uns ein dunnes Glas vor der Thermosaule erforderlich ist, welches die dunklen von den ausseren Teilen der Lampe ausgesendeten Wirkungwahlen zuruckhalt. Bei diesen Lampen ist das Enthaltens vom Licht zur Gesamtstralung konstant; die Energiekurve entspricht also genau der Lichtkurve. Bei Bogenlampen ist wie gesagt eine gewisse Vorsicht am Platze. Jedenfalls kann man sich aber auch hier die Arbeit wesentlich erleichtern, auch wenn man jeder Kontrolle die optische Messung unter 2 bis 3 verschiedenen Winkeln ausfuhrt.

Bemerken möchte ich bei dieser Gelegenheit, dass bei der Prüfung von Bogenlampen mit Glocken, Sammeltrichter der Thermosaule eine so weite Offnung besitzen muss, dass dieser offenungswinkel die gesamt Lampenglocke umfasst, da in diesem Falle die ganze Glocke an der Beleuchtung einer Flachenelementes teilnimmt.

Besonders wertvoll und einwandfrei scheint auch mir das Verfahren zur Aufsuchung der Lichtschwankungen der Bogenlampen, da eine Methode diese ungemein wichtige Eigenschaft der Lampen zu prüfen bisher nicht existiert.

Mit vorzuglicher Hochachtung,
DR. W. VOEGE.

It is necessary to distinguish between the application of my method to such sources as glow-lamps, incandescent mantles, &c., on the one hand, and arc lamps—and especially flame arc lamps—on the other. In the case of glow-lamps experiments with the thermopile must always give correct results, if only a sufficiently great distance is selected between the thermopile and the lamp. This is rendered possible by the use of the requisite thin sheet of glass, which is placed in front of the face of the thermopile, and retains the "dark" invisible radiation from the lamp. In the case of this lamp the relation between the luminous and total energy of radiation is constant; hence the polar curve of energy exactly corresponds to the curve of distribution of light. But, in any case, the work can be considerably simplified by checking the results, at several angles, by means of optical measurements.

I may take this opportunity of remarking that in testing glow-lamps surrounded by globes, the angle of entrance of the collecting apparatus attached to the thermopile should include the entire radiating surface of the source, for in such a case the whole globe contributes to the illumination of a surface-element.

The apparatus seems to me especially useful and free from objection when applied to the study of the fluctuation in light from arc lamps, for there has previously been no satisfactory method of testing this exceedingly important quality. I am,

Yours very sincerely,
DR. W. VOEGE.

Review of the Technical Press.

Illumination.

Some papers of exceptional interest have again been read before the Illuminating Engineering Society in the United States on questions connected with the architect's view of illumination, and the æsthetic aspects of the problem generally.

That by Mr. Elliott, which comes as an interesting contrast to the previous paper by Mr. Basset Jones, deals with the feeling of the engineer for these aspects. He realizes that there is much in the illumination of a building which cannot be satisfied by mere good illumination from the purely utilitarian aspect of a certain general illumination of so many candle-feet. On the other hand he raises the question how far, after all, architects are justified in imposing conditions mainly associated with the architecture of the past, which naturally came into being when science and illumination were in a very different state from what they are now. Strictly speaking the conditions of the present scientific age have yet to evolve an architecture of their own, and it seems rather arbitrary on the architect's part to insist on imitating the dim illumination and ancient sources of light of the past ages. In certain cases where religious and historical associations are of paramount importance this may be desirable; but this is by no means invariably the case.

Another interesting contribution was that of Mr. G. L. Hunter, who dealt with light and colour in decoration. One point specially emphasized by him was that light which is allowed to fall on the walls and ceilings of a room is frequently very far from being wasted. As a rule it is bad policy to concentrate all the light upon the reading table and allow the rest of the room to remain in obscurity, for the eyes are troubled by the constant changing from light to darkness and their consequent efforts after accommodation. But apart from this, we must also remember that the walls of a building may themselves possess a certain decorative value, and are therefore deserving of illumination in order to show off their attractive qualities. Indeed, artificial light, wisely used, enables us to do this more effectually than by daylight, being more under control.

Mr. Hunter also dealt with the effects of various types of diffusing and coloured shades, and supplied a number of hints regarding their tasteful and effective use for decorative purposes.

Mr. W. H. Y. Webber contributes a few remarks on the subject of the comparison of lighting effects in street-illumination. He refers briefly to the part played by the polar curve of distribution of a source in affecting the evenness of illumination secured from it, and also alludes to the difficulty of adequately gauging the usefulness of this illumination by the existing methods of testing. A considerable amount of discussion has been recently raging round this point in the technical press, chiefly referring to the question of whether or no the illumination should be measured in a horizontal plane. Mr. Webber emphasizes the view that in any case mere measurements of "candle-feet" can only be regarded as an index, and by no means finally settle the question of whether the illumination is all that can be desired.

An article in the *Elektrotechnischer Anzeiger* (March 12th) discusses the relative merits of direct and indirect illumination. The main advantages of both methods are summarized, and a numerical example is given. The writer concludes that indirect illumination may answer best in cases in which the height of the room is not more than 4 metres; otherwise direct illumination is preferable.

Several exceptionally interesting reports of commissions have recently been published, notably those referring to lighthouse administration and the future work of the National Physical Laboratory.

The former deals mainly with the question of whether or no it is desirable to amalgamate or refer to a single central authority the separate authorities at present responsible for the coast-illumination of England and Wales, Scotland and Ireland. Apart from the main object of the inquiry, the evidence given before the commission serves to illustrate the wideness of the problems occurring in lighthouse illumination. A coast-light may have many

and various functions to perform—may, for instance, be merely intended to be seen a great way off or may actually serve to illuminate the waterway or entrance to harbours, &c. In each case distinct qualities and a different order of brilliancy on the part of the illuminants may be required. Again, the whole question of the system of rating the illuminating power of these lights calls for careful study, and there seems to be some confusion about the point at present.

The report on the National Physical Laboratory is concerned primarily with the exact variety of work which the institution may be encouraged to carry out without entering into competition with private testing concerns.

Much of the evidence given before the commission relates to the desirability of adopting standard methods of rating glow lamps, it being suggested that such tests should be carried out at the National Physical Laboratory. The important nature of the work of the Laboratory relating to the preservation of standards of light, &c., renders the question under discussion of special import. The report of the Laboratory is also available and contains a record of the photometrical work of the past year. The suggested programme for the early part of the present year is also touched upon, and includes experiments with the Violle standard in accordance with the recommendations of the International Photometrical Commission at Zürich of last July. The report also contains an illustrated description of some of the photometric arrangements at the laboratory.

Paulus (*E.T.Z.*, Feb. 20th) describes the efficiency meter of Hyde and Brooks and also the watt photometer of the Everett and Edgcumbe type. He also gives the results of some of his own tests on the latter, in which the actual readings on the instrument are compared with the actual values of the illumination tested by "precision photometry."

P. G. Nutting (Bull. Bureau of Standards, *Elec. World*) describes some experiments designed to test the value of tubes containing helium gas, as standards of light. His experiments include investigation into the relation between current-density and light, the effect of internal pressure, diameter of tube, &c. As a result it seems to have been found that such tubes possess great possibilities as standards, for the conditions under which the gas is stimulated electrically and caused to give out light can be reproduced with great exactness. Therefore the tubes might serve as a standard of reference, though their life is at present only about 50 hours or so. The colour of the light yielded by the Helium-tube is yellowish-white in character which renders it very convenient for comparison with glow lamps, &c.

Electric Lighting.

A paper of great scientific interest was recently read by Dr. Karl Sartori in Vienna (*Elektrot. u. Masch.*, March 22nd) which discussed the oft-raised question as to how far the better efficiency of the metallic filament lamps can be ascribed to higher temperature — whether, indeed, the temperature of the carbon lamps is actually higher than that of the metallic filament lamp at all.

Dr. Sartori prefaced the subject proper of his paper by a general description of the nature of solid radiation. In particular he drew attention to the fact that the eye is most sensitive to the yellow-green region of the spectrum lying between the D and E lines, and that this seems to be a natural consequence of the fact that the energy maximum of sunlight, rightly studied, proves to occur in this region also. We must, therefore, try to increase the temperature of radiation of our sources of light so as to bring the energy-maximum nearer to this point. Actually to reach this point would require a temperature of approximately 6,000 degrees. In the case of glow lamps we are naturally unable to improve the efficiency by adding a linear spectrum, for this variety of luminous radiation is not characteristic of incandescing solids.

In general the energy maximum of a solid incandescent body which can be regarded as "black" can be predicted when once we know the temperature of incandescence by means of the law of Wien. This states that, $\lambda_m \times T = \text{Constant.}$, where λ_m is the wave length corresponding to the position of the energy maximum and T the absolute temperature of incandescence. It is, however, possible for a solid body to deviate from the black-body law and prefer to radiate certain kinds of energy. In that case it is said to exercise "selective radiation" and does not obey the law of Wien. Thus it is possible for the temperature of a filament to be lower than the position of its energy maximum would suggest.

Dr. Sartori then goes on to describe some experiments of his own on this point. He studied the position of the energy maximum of the grating spectra both of a metallic filament lamp running at 1 watt per c.-p. and a carbon filament lamp taking 3·5 watts per c.-p., and

found that the maximum was situated nearer the violet end of the spectrum in the case of the carbon lamp. This would lead one to suppose that the temperature of the latter was the higher in spite of its lower efficiency.

Much difference of opinion on this point evidently still exists. Prof. Grau mentioned that Dr. Lummer had estimated the temperature of the carbon lamp to be about 2,100 degrees Centigrade, but actually bolometric measurements of Pringsheim and Kurlbaum had placed the value nearer 1,600 to 1,800 degrees Centigrade, and the law of Wien probably does not rigidly hold. Nevertheless it is still generally supposed that the higher efficiency of the metallic filament lamp is merely ascribable to higher temperature: there are, however, others who have been led to the same result as Dr. Sartori. Drs. Blau and Lombardi, for instance, assigned a temperature of about 1,460 degrees Centigrade to the Osmium lamp.

An informal address on the subject of incandescent lamps was also recently delivered to the Electrical Contractors' Association in London by Mr. Leon Gaster. He discussed the merits and disadvantages of the new lamps, and described the recent progress in their manufacture. The value of small step-down transformers at the supply mains also came in for mention, Mr. Gaster urging the contractors to consider each case brought before them on its merits, and not to run any risk of doing harm to the industry by recommending the metallic filament lamps indiscriminately. Small transformers for metallic filament lamps also form the subject of a recent article in *Electrical Engineering*, a number of the chief makes being described with illustrations.

A very complete history of recent progress in all the details of glow-lamp manufacture occurs in recent numbers of the *Zeitschrift für Beleuchtungswesen* (Feb. 29th, March 10th and 20th); references to the most important patents on the subject are given.

A new form of enclosed flame arc lamp has recently been brought out in England by the Jandus Arc Lamp Co. One of the chief points in the lamp is the specially designed system of ventilation, by means of which, it is claimed, the deposition of fumes on the interior of the globe mechanism is entirely avoided.

Auerbacher (*Electrical World*, Feb. 29th) contributes a short note on the lighting of Berlin. It is stated that the ordinary carbon filament lamp has practically disappeared, and that nearly all the commercial lighting of the city is carried out by means of flame-arc lamps. Some firms make a speciality of attending to the maintenance of these lamps for customers, and, as many blocks employ 50 or more arcs in all, the business is worth cultivating. An editorial on the same subject suggests that the ordinary arc lamp is bound to give way to the high candle-power metallic filament glow-lamps in the United States, though flame-arcs may be retained where high candle-power is very essential.

Gas, Oil, and Acetylene Lighting.

Mention may next be made of some recent lectures by Prof. Vivian Lewes. The first of these dealt with the theory of the incandescent mantle (see *J.G.L.*, March 3rd). The lecturer summarized the history of the incandescent mantle in a popular manner, prefacing his lecture with a few remarks on the development of gas-burners in general, as illustrated by the work of Wenham, Sugg, and others. Naturally the possibility of the incandescent mantle demanded a convenient form of high-temperature flame, and no progress could be made until the arrival of the Bunsen burner about 1852. Previously a genuine incandescent light had existed in the limelight, which dates from 1826. A basket of magnesium rods, rendered incandescent in the bunsen flame was brought out in 1882, but nothing great was done until the eventual solution of the difficulties of the mantle by Welsbach's mixture of 1 per cent. of cerium with 99 per cent. of thorium.

It is, however, still a mystery exactly why this particular proportion of these two substances should be essential. The lecturer mentioned a few of the various theories still in the field—the catalytic theory, the theory of luminescence, &c. One fact against the theory of high temperature pure and simple was the fact that the mantle would continue to glow a short time after the flame was turned out. This was illustrated by experiment. Finally, some details were given of the various methods of forming the mesh of the mantle, mention being made of the recent Plaissety process.

Prof. Lewes has also been delivering the Cantor Lectures before the Society of Arts. While mainly dealing with the question of fuel, these lectures contain many points of great interest in the generation of illuminating gas. One recent lecture, for instance, brought out the difference in the nature of the products obtained by distillation at high and low temperatures. In the latter case a smaller yield of gas is obtained, but it is of a higher illuminating

power and calorific value. The by-products are also such as to lead the lecturer to suggest that it might pay the gas-producer to adopt a lower temperature distillation in preference to the present system.

Mr. Thos. Newbigging has recently spoken on the question of illuminating values. Now that the incandescent mantle is becoming more and more universally employed, gas-engineers are anxious to obtain a calorific basis of testing as soon as possible, and, meanwhile, are tempted to reduce the illuminating power, especially in fortunate circumstances, where the great majority of consumers have been converted to the incandescent system. He intimated that the time was not yet ripe for any violent changes. The vast majority of consumers were still chiefly interested in the illuminating power of the gas they bought, and any attempt to hurry matters might prove of doubtful benefit to the industry as a whole.

Dr. Rideal has published the results of a series of investigations into the hygienic value of electricity and gas as illuminants. In these experiments a room is divided into two similar sections, illuminated by gas and electricity respectively. An attempt was then made to compare the various phenomena which might be expected to be injurious to health in these two cases. Among such effects we may mention the effect of carbon-dioxide and other gaseous substances given off by gas. The main conclusion drawn by Dr. Rideal from these experiments seems to be that neither illuminants could be said to show any very distinct signs of prejudicial action. The conditions under which the experiments were undertaken, however, precluded the intentional production of very adverse circumstances.

A discussion between the junior members of the institutions of Gas and Electrical Engineers took place in Manchester last month on the merits of gas and electricity. While the discussion did not, perhaps, elucidate any very novel points, it was at least notable as an instance of a growing feeling of toleration between the representatives of the different systems of illumination.

Stephenson (*J.G.L.*, March 10th) describes a system of automatic control of street-lighting; this system involves the lighting and extinguishing of street lamps by means of regulated waves of pressure in the town mains. The lighting up and extinguishing of the street lamps is accomplished by a temporary increase in the gas pressure of about 1 to 1½ in., maintained for about half a minute to a minute and a quarter. The wave of pressure is stated to travel very quickly, acting practically instantaneously at a distance of two miles. The method is said to have worked very satisfactorily and to have led to a considerable annual saving both in attendance and in reduction of breakages of mantles, &c. No irregularities of the mechanism have been experienced. Some interesting figures as regards the saving in mantles, rods, and glasses are also given in the Table. The great saving in the year 1907, when the system first came into general use, is very marked.

Year.	Mantles.	Rods.	Glasses.
1903	6,445	968	4,099
1904	6,806	858	2,891
1905	7,195	689	4,255
1907	4,508	333	2,248

Altogether the saving in gas, labour, and maintenance may amount to 300*l.* per annum. The cost of installing the apparatus comes to about 1*l.* per lamp. The only possibility of trouble has been the occasional extinguishing of pilot-flames by wind, against which, of course, every system of automatic control has to contend. This merely calls for the use of suitably designed lanterns.

An interesting anticipated difficulty was that street-lamps might have to be lighted slightly earlier in the evening than was really necessary. Otherwise, all the consumers would light up at the same time as the street-lighting began, and cause such a draught in the mains that the lighting wave of pressure would fail to operate. Actually, however, this difficulty did not occur. The apparatus invariably worked satisfactorily, and pressure charts, taken at various lamps distributed over the district, showed the same rise in pressure as that indicated on the chart at the works.

It had been suggested that consumers might resent the temporary change in the light in the one and a half minute during which the wave of pressure was in use; actually, however, no complaints were received. Indeed, in some instances we are told that this involuntary intimation that midnight had arrived was regarded as a convenience.

Recent numbers of the *Zeitschrift fur Beleuchtungswesen* have contained an exhaustive description of newer forms of burners for inverted incandescent mantles, which is accompanied by references to the recent patents on the subject.

MISCELLANEOUS.

Grau and Russ (*Physikalische Zeitschrift*, Feb.) describe some experiments on arcs formed between cooled metallic electrodes. Their object was to ascertain how far Mrs. Ayrton's results are applicable to metallic arcs. This had been already done by Guye and Zebrikoff, but their experiments were confined to short arcs; the authors extend their investigations to arcs of 40 to 50 millimetres in length, with the result that they, too, find that Mrs. Ayrton's results apply.

PHOTOMETRY AND ILLUMINATION.

Elliott, E. L. The Relation of Illuminating Engineering to Architecture from the Engineer's Standpoint (read before the Illuminating Engineering Society, March 12).
Hunter, G. L. Light and Colour in Decoration.
Nutting, P. G. Bull. Bureau of Standards (*Elec. World*, Feb. 22).
Paulus, C. Ein neues Photometer (E.T.Z., Feb. 20).
Vredenburgh, R. T. Spectacular Lighting (*Ill. Engineer*, New York, Feb).
Webber, W. H. Y. On the Comparison of Street-Lighting Effects (G.W., March 21).
Annual Report of the National Physical Laboratory.
Report of Treasury Committee on National Physical Laboratory.
Report of Royal Commission on Lighthouse Administration.
Direkte oder indirekte Beleuchtung? (Elek. Anz., March 12).

ELECTRIC LIGHTING.

Auerbacher, L. J. High-Efficiency Lighting in Berlin (*Elec. World*, Feb. 29; see also Editorial).
Gaster, L. Electric Incandescent Lamps (address delivered to Electrical Contractors' Association, March 12).
Sartori, K. Uber die Temperatur mit welcher Glühlampen Strahlen (*Elektrot. u. Masch.*, March 22).
The Jandus Regenerative Flame Lamp (*Elec. Engineer*, Feb. 28; *Elec. Engineering*, Feb. 27, &c.).
Small Transformers for Use with Metallic Filament Lamps (*Elec. Engineering*, March 5).
Emergency Lights for Residences (*Elec. World*, March 7).
Fortschritte in der Glühlampen-industrie (Z. f. Bel., Feb. 29, March 10 and 20).

GAS, OIL, ACETYLENE, &c., LIGHTING.

Günther. Schwimmenbadenbeleuchtung mit Gas (J. f. G., Feb. 29).
Lewes, Prof. Vivian. The Theory of the Incandescent Mantle (J. G. L., March 17; G. W., March 14).
Fuel and its Future (Cantor Lectures before the Society of Arts).
Newbigging, T. Incandescent Gas Lighting: a Word of Caution (J. G. L., March 3; G. W., March 7).
Rideal, S. The Relative Hygienic Values of Gas and Electricity (J. G. L., March 10; G. W., March 14).
Stephenson, S. O. The Automatic Control of Street-Lighting at Tipton (J. G. L., March 10).
Wedding, W. Uber hängendes Gasglühlicht (J. f. G., March 7).
Neue Invertbrenner (Z. f. Bel., Feb. 20 and 29, March 10 and 20).
Gas and Electricity as Illuminants (discussion held between members of Junior Institutions of Gas and Electrical Engineers in Manchester).
The Bijou Inverted Burner in Westminster Abbey (J. G. L., March 10; G. W., March 14).
Some further Remarks upon Gaslighting in the United States (J. G. L., March 10).

MISCELLANEOUS.

Grau and Russ. A Study of the Continuous Current Arc between Cooled Metallic Electrodes (*Phys. Zeitschrift*, Feb. 1).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
Elektrot. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal fur Gasbeleuchtung und Wasserversorgung.*
Z. f. Bel.—*Zeitschrift fur Beleuchtungswesen.*

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

3,388. Incandescent lamps (C.S.). Feb. 14. (I.C., Aug. 7, 1907, U.S.A.) J. W. Howell, 83, Cannon Street, London.
3,715. Electroliers. Feb. 19. R. S. Woods, 4, St. Ann's Square, Manchester.
4,174. Mineralized carbons. Feb. 25. H. E. Moul, 18, Kensington Court Place, London.
4,212. Arc lamps. Feb. 25. H. Baggett, Norfolk House, Norfolk Street, Strand, London.
4,350. Locking incandescent lamps in their holders. Feb. 26. B. H. Morphy, Queen Anne's Chambers, Westminster.
4,568. Arc lamps (C.S.). Feb. 28. C. A. Taylor and E. R. A. Broom, trading as The New Century Arc Light Co., Norfolk House, Norfolk Street, Strand, London.
4,608. Holders for electric lamps. Feb. 29. F. W. Suter, Chancery Lane Station Chambers, London.
4,668. Arc lamps. March 2. A. Holman, 44, West George Street, Glasgow.
4,760. Conducting connection for use in incandescent lamps (C.S.). March 2. H. W. Lake, 7, Southampton Buildings, London. (From Elektrische Gluhlampenfabrik Watt, Scharf, Loti & Latzko, Austria.)
4,774. Key switch lamp holder. March 3. G. H. Ide, 152, Sherlock Street, Birmingham.
4,922. Electric lamps and their circuits. March 4. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
4,956. Incandescent bodies for lamps (C.S.). March 4. F. J. Planchon, 40, Chancery Lane, London.
4,957. Enclosed arc lamps. March 4. W. J. Davy, 40, Chancery Lane, London.
4,977. Arc lamps. March 5. A. D. Jones, Hartham Works, Hartham Road, Holloway. London.
5,029. Arc lamps. March 5. Johnson & Phillips, Ltd., and S. Paterson, Birkbeck Bank Chambers, Southampton Buildings, London.
5,040. Metallic filaments or rods for incandescent lamps (C.S.). March 5. (I.C., Nov. 9, 1907, France.) F. J. Planchon, 40, Chancery Lane, London.
5,225. Electrodes for arc lamps (C.S.). March 7. (I.C., July 5, 1907, Germany.) Allgemeine Elektricitäts Ges., 83, Cannon Street, London.
5,231. Arc lamps. March 9. Verity's Ltd., and C. B. Walker, 11, Burlington Chambers, New Street, Birmingham.
5,372. Reflectors for electric lamps. March 10. J. Bein, 205A, Pentonville Road, London.
5,387. Incandescent lamps (C.S.). March 10. A. G. Bloxam, Birkbeck Bank Chambers, Southampton Buildings, London. (From Siemens and Halske, Akt.-Ges., Germany.)
5,415. Incandescing bodies containing zirconium. March 10. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
5,416. Filaments for incandescent lamps. March 10. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
5,560. Incandescent lamps. March 12. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
5,596. Mercury or metallic vapour lamps. March 12. H. A. Kent, H. G. Lacell, and The Silica Syndicate, Ltd., 47, Lincoln's Inn Fields, London.
5,681. Electric light fittings. March 13. F. M. Long, 77, Chancery Lane, London.

II.—GAS LIGHTING.

3,450. Inverted incandescent gas fittings. Feb. 15. M. Slomnitzkie, 37, West Nile Street, Glasgow.
3,593. Bunsen burners for incandescent light. Feb. 17. P. Wigley, G. N. Arculus, and J. Warry, trading as A. Arculus & Co., 128, Colmore Row, Birmingham.
3,785. Filaments for incandescent mantles (C.S.). Feb. 19. (I.C., Oct. 11, 1907, France.) R. Laigle, 6, Lord Street, Liverpool.
3,814. Holding globes of inverted burners. Feb. 20. G. N. Arculus and J. Warry, 128, Colmore Row, Birmingham.
4,073. Pressure regulators for use with gas burners. Feb. 24. C. C. Broad, 24, Temple Row, Birmingham.
4,415. Gas lamps and burners. Feb. 27. G. Helps, 1, Izon's Croft, Ansley, near Atherstone.
4,451. Inverted incandescent burners (C.S.). Feb. 27. M. Graetz, 18, Southampton Bldgs., London.
4,520. Supports for upright incandescent mantles. Feb. 28. G. Sunnucks, 19, Farringdon St., London
4,549. Inverted incandescent lamps (C.S.). Feb. 28. (I.C., May 1, 1907, Germany.) M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.
4.550. Electrically igniting gas burners. Feb. 28. A. J. Hill and F. C. D. Mann, 60, Queen Victoria Street, London.
4,636. Gas burners (C.S.). Feb. 29. A. Felchlin, 33, Cannon Street, London.
4,652. Inverted incandescent burners. Feb. 29. G. H. Barber and S. R. Barrett, 18, Southampton Buildings, London.
4,659. Incandescent burners. March 2. H. Nehmer, 36, Clifford Street, Finsbury Square, London.
4,661. Incandescent lamps. March 2. H. R. Prosser, 5, Corporation Street, Birmingham.
4,885. Electrically controlled gas lighting devices. March 4. J. C. A. Maddick, 34, Castle Street, Liverpool.

4,986. Inverted incandescent burners. March 5. R. T. Grocott, Whitehall Works, Longport, Stoke-on-Trent.
5,031. Incandescent lamps. March 5. E. H. Still, 46, Lincoln's Inn Fields, London.
5,273. Supporting mantles of incandescent lamps (C.S.). March 9. B. A. Manning, "Montrose," South End Road, Hampstead.
5,356. Gas burners and incandescent lamps. March 10. J. W. Bowley, Aintree Villa, Court Oak Road, Harborne, Worcester.
5,381. Gas lanterns. March 10. W. Sugg & Co., Ltd., and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.
5,474. Incandescent lighting. March 11. A. W. Norris and W. G. Clinch, 91, Beechdale Road, Brixton Hill, London.
6,626. Incandescent burners. March 13. H. Darwin, 24, Temple Row, Birmingham.

III.—MISCELLANEOUS.

(Including lighting by unspecified means, and inventions of general applicability.)

3,899. Incandescent gas and oil lamps. Feb. 21. J. Royle and J. Darbyshire, 139, Dale Street, Liverpool.
4,208. Oil or gas lamps. Feb. 25. F. A. Lewis and R. S. Pike, 41, Earlsfield Road. Wandsworth, London
4,260. Lamps. Feb. 25. H. Salsbury and T. Whitaker, 18, Southampton Buildings, London.
4,461. Filaments for illuminating and heating (C.S.). Feb. 27. (I.C., June 10, 1907, France.) G. Michaud and E. Delasson, 7, Southampton Buildings, London.
4,856. Lamps. March 3. G. Epstein, 54, Willow Road. Hampstead, Middlesex.
5,209. Acetylene flare lights (C.S.). March 7. C. C. Wakefield, 111, Hatton Garden, London. (Addition to 11,758/05.)

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

28,600. Arc lamps. Dec. 14, 1906. Accepted Feb. 26, 1908. H. Beck & Deutsche Beck-Bogenlampen Ges. m. b. H., Thanet House, Temple Bar, London.
28,601. Arc lamps. Dec. 14, 1906. Accepted Feb. 26, 1908. H. Beck & Deutsche Beck-Bogenlampen Ges. m. b. H., Thanet House, Temple Bar, London.
2,587. Arc lamps. Feb. 1, 1907. Accepted March 11, 1908. A. Howard, 6, Lord Street, Liverpool.
9,172. Arc lamps. April 19, 1907. Accepted Feb. 19, 1908. E. R. Ingram and H. Hunt, 40, Chancery Lane, London.
9,572. Lamps with metallic incandescing bodies. April 24, 1907. Accepted Feb. 19, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.).
9,591. Supporting carbons in arc lamps. April 25, 1907. Accepted Feb. 26, 1908. O. Gross, 5, John Dalton Street, Manchester.
13,354. Attaching filaments to leads in incandescent lamps. June 8, 1907. Accepted March 4, 1908. F. P. Driver, 55, Gordar Gardens, West Hampstead, London.
18,243. Arc lamps (C.S.). Aug. 12, 1907. Accepted March 11, 1908. S. Szubert, Thanet House, Temple Bar, London.
18,681. Arc lamps for search lights. Aug. 19, 1907. Accepted March 4, 1908. Siemens Bros. Dynamo Works, Ltd., and E. A. Holmes, 139, Queen Victoria Street, London.
3,283. Electrodes for arc lamps (C.S.). I.C., Feb. 16, 1907, Germany. Allgemeine Elektricitäts Ges., 83, Cannon Street, London.
3,464. Arc lamp (C.S.). I.C. Feb. 18, 1907, Sweden. L. S. Andersson, 65, Chancery Lane, London.
3,465. Carbon holder for arc lamps (C.S.). I.C. Feb. 18, 1907, Sweden. L. S. Anderson, 65, Chancery Lane, London.
4,762. Electrodes for arc lamps (C.S.). I.C. March 1, 1907, Germany. Allegemeine Elektricitäts Ges., 83, Cannon Street, London.
5,318. Sockets for incandescent lamps (C.S.). I.C. March 15, 1907, U.S.A. F. A. Swan, 72, Cannon Street, London.
5,610. Incandescent lamps (C.S.). I.C. March 14, 1907, Germany. Allgemeine Elektricitäts Ges. 83, Cannon Street, London.

II.—GAS LIGHTING.

2,563. Inverted incandescent lamps. Feb. 1, 1907. Accepted March 11, 1908. P. Wigley and G. N. Arculus, trading as Alfred Arculus and Co., 128, Colmore Row, Birmingham.
3,706. Inverted incandescent lamps (C.S.). Feb. 14, 1907. Accepted Feb. 19, 1908. A. Pöschl, 40, Chancery Lane, London.
5,135. Incandescent burners. March 2, 1907. Accepted March 11, 1908. J. Galilé, 53, Chancery Lane, London.
5,171. Flashlight apparatus (C.S.). March 4, 1907. Accepted Feb. 26, 1908. E. Wagmüller, 3, Stubenrauchplatz, Steglitz, Berlin.
6,323. Incandescent lamp. March 15, 1907. Accepted Feb. 26, 1908. W. C. Fairweather, 65, Chancery Lane, London (From the firm of Julius Hardt, Germany).
7,367. Gas lighting apparatus. March 27, 1907. Accepted Feb. 26, 1908. A. E. Broadberry, 173, Fleet Street, London.
13,343. Anti-vibration device for mantles. June 8, 1907. Accepted March 4, 1908. E. Wills and F. Knott, 56, Oldham Road, Ashton-under-Lyne.

14,161. Incandescent burners. June 19, 1907. Accepted Feb. 26, 1908. H. Wakefield, 24, Temple Row, Birmingham.
14,884. Gas pendants. June 29, 1907. Accepted Feb. 26, 1908. W. Beal, 128, Colmore Row, Birmingham.
16,292. Inverted burners. July 16, 1907. Accepted March 4, 1908. W. D. Marshall and W. Denholm, 104, Spottiswoode Road, Edinburgh.
18,415. Gas lamps (C.S.). I.C., May 15, 1907, U.S.A. Accepted Feb. 19, 1908. A. H. Humphrey, 6, Lord Street, Liverpool.
22,822. Inverted burners (C.S.). I.C., July 3, 1907, Germany. Accepted Feb. 19, 1908. Firm of Ehrich and Graetz, 1, Broad Street Buildings, Liverpool Street, London.
796. Electrically controlled apparatus for igniting and extinguishing lamps (C.S.). Jan. 13, 1908. Accepted March 4, 1908. A. M. Aubert and J. M. Aubert, Birkbeck Bank Chambers, Southampton Buildings, London.
1,881. Inverted incandescent burners (C.S.). Jan. 28, 1908. Accepted March 4, 1908. G. Cranmer and H. Cheshire, trading as Cranmer & Cheshire, Carlton Buildings, Paradise Street, Birmingham.
2,384. Burners for lighting and heating (C.S.). I.C., Feb. 6, 1907, France. A. Mouneyrat, 111, Hatton Garden, London. (Addition to 18,701/06.)
2,973. Inverted incandescent pressure lamps (C.S.). I.C., Feb. 26, 1907, Germany. M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

5,400. Illuminant appliances. March 6, 1907. Accepted March 11, 1908. G. Calvert, Birkbeck Bank Chambers, Southampton Buildings, London.
13,241. Valves for hydrocarbon lighting fixtures (C.S.). June 12, 1907. Accepted March 4, 1908. M. W. Pitner, 615, F Street, N.W., Washington, D.C., U.S.A.
14,522. Acetylene burner tips (C.S.). June 24, 1907. Accepted March 11, 1908. E. J. Dolan and M. J. Tracy, 111, Hatton Garden, London.
20,514. Producing intermittent light (C.S.). Sept. 14, 1907. Accepted Feb. 26, 1908. J. C. F. Jürgens and F. R. W. Schroeter, 7, Southampton Buildings, London.
25,277. Lamps (C.S.). Nov. 14, 1907. Accepted Feb. 26, 1908. F. W. Kearsey, 111, Hatton Garden, London.
26,804. Illuminated glove and hosiery holders (C.S.). Dec. 4, 1907. Accepted Feb. 26, 1908. A. P. Graupner, 20, High Holborn, London.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.
(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.
(D.A.) Divided application; date applied for under Rule 13.
Accepted.—Date of advertisement of acceptance.
In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.
Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.
Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.
N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

TRADE NOTES.

The Jandus Regenerative Flame Lamp.

We have received particulars of a new form of flame arc lamp, the invention of Mr. A. Denman Jones, the manager of the Jandus Arc Lamp Co.'s Works. This lamp is manufactured at the Jandus works in Holloway, and put upon the market by Messrs. Drake & Gorham, of Victoria Street.

Transformers for Use with Metallic Filament Lamps.

A leaflet has been issued by Messrs. Johnson & Phillips dealing with small transformers for house-service conditions. These transformers are listed in three sizes for reduction from 200 to 25, 50, or 100 volts respectively. With a reduction to 25 or 50 volts and an output of ¼-kilowatt the full lead efficiency is stated to be 86·5 per cent., while in the case of higher outputs greater efficiency is attained.

Excello Arc Lamps.

This attractive leaflet, issued by the Union Electric Co., gives a complete and interesting account of the Excello lamps, including the results of tests and advice as to maintenance. The leaflet concludes with a series of photographs illustrating the installation of Excello lamps in the Albert Hall and other buildings.

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The
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OIL · GAS
Edited by
LEON · GASTER

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EDITORIAL.

The Education of the Illuminating Engineer.

THE progress of the illuminating engineering movement in the United States since the inauguration of the Illuminating Engineering Society, two years ago, has been exceedingly rapid. One of the most striking facts brought out by the doings of the society has been the great variety of subjects coming under the notice of the illuminating engineer, and the number of experts of different callings who have come forward to express the views of their respective professions, thus bringing about friendly co-operation and better mutual understanding.

In this connexion the summary of papers read before the society, which we reproduce elsewhere in this issue, should be of interest at the present moment. The list includes papers by engineers, makers of fixtures, &c., architects, professors, members of the medical profession, and others representing many different sections of the engineering profession. It will be seen that the range of subjects dealt with is very wide indeed. Space does not allow us to recapitulate these in detail. We invite our readers to read the titles over and form their own conclusions as to the vastness of the branch of knowledge with which the expert illuminating engineer must make himself acquainted.

There can be no doubt as to the need for men who are really well acquainted with the principles of illumination; the only difficulty at present has been to find those who were properly qualified in this respect. We note that this question is now receiving special recognition in the American universities and technical institutions. Professor Wickenden, of Wisconsin University, and others have described the work that is being done in this connexion in a recent number of our contemporary 'THE ILLUMINATING ENGINEER' of New York.

The university of Wisconsin has been developing a course in illumination for some years past, and at the present time students are not only instructed in the principles underlying the production and measurement of light, but also in the application of these principles to actual practical problems. Similar courses are held at Columbia and Cornell Universities, at the Carnegie Institute, the Stevens Institute, the Massachusetts Institute of Technology, and other similar institutions. In these cases the study of illumination may be said to form a definite integral part of the syllabus. At present stress is laid chiefly on giving the students a grounding in the theoretical side of the subject, and in making them familiar with the fundamental laws of light, as applied to illumination.

We are glad to note that this point is not being lost sight of in this country, and feel confident that the subject of illumination will soon become a recognized portion of the curricula of our engineering institutions. In particular we wish to point out in this connection the syllabus adopted at the Northampton Institute, where Dr. Drysdale, one of the eminent supporters of the illuminating engineering movement in this country, is conducting a course of lectures in *illumination*. Dr. Walmsley, the Principal, is clearly turning to account some of the experience gained in his visit to the States.

It is true that at present a certain amount of information of great value to the illuminating engineer is to be gained in the courses given at many of our leading institutions. It must be recognized, however, that there are several respects in which improvement in the existing facilities is desirable. Students, for instance, may receive useful instruction in photometry, but this instruction is seldom extended to such actual problems of illumination as occur in practice. Again, they frequently listen to lectures embracing a study of one or other of the existing illuminants, incandescent, electric and arc lamps for example, but rarely do all methods of lighting receive a fair share of attention; the result is that the student goes out with an understanding of only one narrow aspect of the question. But the most serious objection to the existing systems is the fact previously mentioned, that while the production of light and its measurement receive attention, the really vital question of the actual application of this light to the illumination of streets and buildings is invariably ignored. As a result, photometry and the whole subject of scientific standardization of light-sources and illumination come to be regarded by the student as misty and unpractical processes which are of merely scientific interest, and are not strictly applicable to practical conditions.

We are, therefore, strongly in favour of the subject of illumination, including the application of theoretical results to practical lighting problems, forming an integral portion of the course of study in technical colleges. There also seems good reason to suggest that instruction of a simple and practical character might in future be given at the technical schools which are under the direction of the L.C.C.

In any case it may safely be predicted that the ever-increasing interest that is being taken in matters of illumination will in time prove the necessity for the creation of courses of study of the nature indicated. The great strides that are continually being made in all varieties of existing illuminants only serve to indicate yet more clearly how essential it is that those dealing with any particular type should make themselves thoroughly acquainted with recent progress in other branches, and there can be no question but that the company that secures representatives with this qualification will reap a very great advan-

tage in its dealings with the consumer. This naturally leads to the consideration of the second subject with which we propose to deal on this occasion.

The Standpoint of the Consumer.

We reproduce elsewhere in abstract the recent interesting paper read by Messrs. Handcock and Dykes, before the Institution of Electrical Engineers, dealing with the influence of metallic filament lamps on the electrical industry. The importance of the situation can hardly be denied, and in our next number we propose to enter into greater detail in considering the suggestions of the authors and the discussion to which they have given rise. For the moment we only wish to draw attention to a few important phases of the subject from the standpoint of the general public. For, after all, the welfare of any supply-company depends on the satisfaction it gives to the consumer. One practical result of the competition between gas and electricity as illuminants has been the gradual recognition of the wisdom of treating the public in a less arbitrary and more courteous manner than was prevalent in the past. Fortunately there is ample evidence that the old feeling of hostility is being replaced by mutual goodwill and understanding.

With this end in view, we think that the electrical supply companies should be prepared to make some sacrifice in order to avoid the imposition of any complicated method of charging, or any other feature of their system which the consumer finds burdensome or difficult to follow. Electricity is undoubtedly at a disadvantage in the multiplication of charging systems which exist, and any attempt to secure greater uniformity deserves every encouragement.

In order to secure the consumers' confidence the supply company, whether furnishing gas or electricity, ought to do all in their power to assist him to make the best use of the power put at his disposal. To effect this purpose it is most essential that canvassers should be employed having a really practical and efficient knowledge not only of the illuminant with the use of which they are mainly concerned, but also of other systems also at the disposal of the consumer. Indeed the consumer himself is now taking a keener interest in the merits of different illuminants, and he will not readily be satisfied by any but a tolerably complete knowledge of this description. A canvasser wishing to induce him to adopt any system of lighting must be prepared to answer inquiries dealing with other methods, and to show him how to get the very best results from the gas or electricity with which he is supplied. This canvasser must, in fact, be conversant with the principles of illuminating engineering. It must now also be recognized that the actual care of the generating plant, and the consideration of the conditions at the consumer's end, are two distinct functions, and it is too much to expect from a single man (the central station manager and engineer) to undertake and carry out both satisfactorily.

The second point to which attention may be drawn is the importance of taking broad views of the fields of action of rival systems of lighting. We have always insisted upon the obvious desirability of those representing two distinct systems of illumination like gas and electricity realizing that there is room for both in their respective spheres, and helping each other instead of wasting money and effort in needless friction.

We should also like to point out that before extending the use of any improved type of lamp the public must first be thoroughly educated to appreciate its merits in particular cases. The indiscriminate pushing of such a lamp under all conditions is more likely eventually to injure than to benefit the lighting industry.

But recent remarkable developments

in illuminants have also contributed to the extension of gas-lighting, and it is not to be expected that an industry employing so many people, and with an invested capital of over 120 million pounds, will be ready to give place to a new system of electric lighting, however great the improvement may appear, without being able to perceive possibilities of remunerative extensions in the other directions.

It therefore seems to us evident that some understanding should be arrived at as to the spheres of action to which the two illuminants are best suited, and that there should be no undue interference in legitimate fields of activity. The definite solution of the problem will probably form part of the services of the impartial and accredited expert whom we desire to see come into existence. Meantime, as has been shown previously, the right to existence of both systems should be recognized, and mutual toleration and good-will might smooth away much of the existing misunderstanding. Those municipal authorities who own both systems of illumination are particularly well placed to practise co-operation of this description, from which the consumer will ultimately benefit.

Gas-Testing in London.

Under the above title Mr. R. A. Dibdin contributes an exceptionally complete description of the modern legal methods of testing gas in force in London, including a record of the existing legislation on the subject. To those readers who are unfamiliar with the regulations relating to gas-testing this article will be of great interest.

One is nevertheless disposed to wonder how far the consumer is in a position to get the full benefit of the tests organized for him. He is adequately protected against the possibility of the gas supplied being of inferior illuminating power, but naturally such precautions avail little if his burners are defective, uneconomical owing to neglect, or placed in such a manner as to distribute the light in an inefficient manner.

Great care is being constantly exercised at the testing stations in order to secure that the gas delivered to his premises comes up to the required standard, but the advantages following are greatly discounted if no adequate provision is made to help him to obtain correspondingly satisfactory conditions from that point onwards. As explained in the previous section, we feel that this duty naturally devolves upon representatives of the supply companies, who now realize that their responsibilities need not stop at the meter. It is very gratifying to note that in some quarters steps are now being taken to educate canvassers on the subject of illumination, and to keep them well posted on recent progress both in their own and other branches of lighting. We hope that this policy will commend itself to other companies.

Abstract of Contents.

We desire to draw the attention of our readers to the short abstract of the contents, which follows this editorial. We realize that certain articles are naturally of greater interest to some readers than to others, but that such readers may nevertheless wish to form an impression of the general contents of the magazine. We, therefore, hope that the present abstract, which we propose to repeat in subsequent numbers, will be found a convenience.

LEON GASTER.

Review of Contents of this Issue.

THE instalment of **Mr. A. P. Trotter's** series of articles in this number is devoted to the discussion of contour lines of equal illumination or "isolux" curves. Such curves enable us to map out the combined illumination of several sources of light at a certain distance apart and height from the ground. In the April number Mr. Trotter had explained the methods by which such curves may be drawn, and he now illustrates his previous explanation by means of practical examples.

Mr. Norton H. Humphrys contributes some general notes on illumination. He points out the wastefulness of many existing methods of using light, and the importance of keeping in view the exact purpose for which any such lights are installed. For instance, the nature of the walls of the interior, the variety of buildings in the streets, and the character of goods displayed in shop-windows are all of influence on the correct system to adopt; these remarks are illustrated by examples of every-day conditions to be seen in the streets of London.

Dr. Berthold Monasch discusses the action of different varieties of glass used in windows. He examines four specimens of glass: clear, rippled, frosted, and ribbed respectively, and shows how the light is distributed in each case, and their general effect upon the illumination of the room. He also points out that, while artificial illumination is the subject of constant systematic study very little corresponding attention is expended upon the best utilization of daylight conditions. Yet these are often of at least equal importance.

Dr. Drysdale's present contribution deals with luminous efficiency, and the mechanical equivalent of light. He explains the nature of the radiation in various parts of the spectrum from different illuminants, and proceeds to describe methods by which the radiation can be separated into visible and invisible components, and hence the percentage of energy available in a useful and luminous form computed.

Dr. Paul Krüss describes some forms of apparatus having for their object the screening of the photometer from diffused stray light. This may be accomplished by the cumbrous method of placing screens, provided with suitable orifices, along the photometric bench. Dr. Krüss, however, advocates a special piece of tubular apparatus which is attached to the photometer, and effectually protects the illuminated surfaces from light coming in at the side. When this adjunct to the photometer is employed the greater portion of the bench can be kept free from encumbrances and the inconvenience of screening arrangements is much reduced. Dr. Krüss quotes the results of some actual experiments to show the effect of the apparatus in practice.

Mr. R. A. Dibdin deals with the course of legislation affecting the testing of gas in London, and also describes comprehensively the exact methods by which tests of illuminating and calorific power are carried out by the gas examining authorities. The article is illustrated by a series of photographs showing the nature of the photometers and standards of light, &c., used, and the apparatus in actual operation.

Mr. A. B. Clarke contributes a short article on the calculation of the P.D. drop in supply mains, and its influence upon the light yielded to the consumer. The article is accompanied by a curve showing the relative efficiency of illumination with different pressures at the consumer's terminals.

Dr. F. Jaoobsohn contributes a general review of the recent developments in electric metallic filament lamps. In the first part of the article he passes in review the various substances which may be considered of possible application to the manu-

facture of glow-lamp filaments, and describes, in general terms, the processes of manufacture of tungsten and other metallic filament lamps. In so doing he refers to the most recent German patents on the subject and criticizes their applicability to existing conditions. The second part will follow in the next number.

The Special Section in this number is again devoted to the standpoint of the architect in matters of illumination, the recent paper on the subject by **Mr. Bassett Jones** before the Illuminating Engineering Society, and the discussion to which it gave rise, being exhaustively dealt with. Mr. Bassett Jones's paper, which is accompanied by a number of illustrations, serves to show the importance of due attention being paid to the æsthetic considerations, which are the main inspiration to the architect in inducing him to adopt certain systems of illumination and to discard others. Briefly, Mr. Jones contends for the realization of the fact that objects which are intended to be beautiful serve a distinct and useful purpose, and ought to be illuminated with the specific object of bringing out their value.

The discussion of the paper turned mainly upon the relative predominance of the æsthetic and purely utilitarian aspects of lighting and the spheres of influence of the architect and the illuminating engineer; all, however, agreed that exchange of views and co-operation between members of both professions was desirable.

Dr. Louis Bell's paper on the physiological basis of illumination deals mainly with the alteration in the behaviour of the eye under various conditions of illumination, notably the effect of illumination upon the pupil-orifice. From these data he draws several important conclusions as to the utilization of light under practical conditions....shows, for instance, the unwisdom of lighting a desk or table extremely brightly, and leaving the rest of the room in comparative darkness.

A recent paper by **M. C. Whitaker** before the Illuminating Engineering Society deals with a new form of thermostatically controlled incandescent burner, by means of which the gradual heating up of the burner as a whole is made to regulate the aperture and allow the proportion of gas and air admitted to adjust themselves to exactly the most favourable conditions. The paper also deals in detail with the general principles underlying the inverted gas burner.

The recent paper by **Messrs. Handcock** and **Dykes,** before the Institution of Electrical Engineers, discusses the effect of the development of the metallic filament lamps upon the electric lighting industry.

A new form of **Holophane** reflector intended specially for street lighting is also described, with illustrations. At the end of this number are to be found the usual review of the existing technical literature on the subject of illumination, and the patent list.

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 273.)

Fig. 17 gives the contours for two lamps at a distance apart equal to three times their height. The maximum illumination due to each lamp is 100. The smallest curves, which are indistinguishable from circles, represent an illumination of 90. The resultant maximum is 103·16.

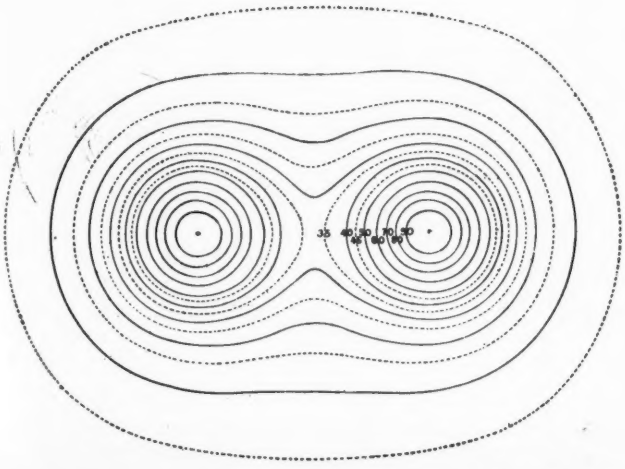


Fig. 17.—Contour lines of equal illumination or iso-lux curves, due to two lights at a distance apart equal to three times their height.

Fig. 18 refers to two lamps at a distance apart equal to four times their height. The smallest curve is 90 and the maximum is 101·4.

If these contours be considered to represent a solid figure, a vertical section gives curves of the kind shown in Figs. 10 to 13. The lowest of the

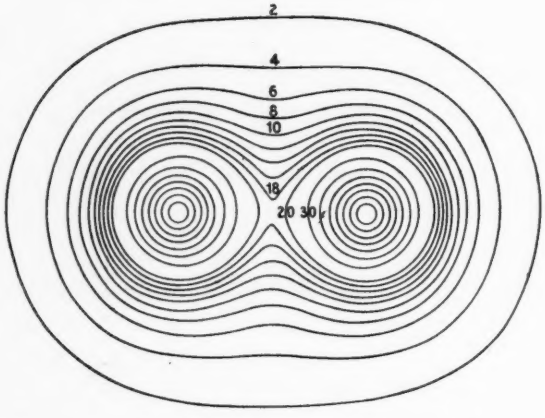


FIG. 18.—Contour lines of equal illumination, or iso-lux curves due to two lights at a distance apart equal to four times their height.

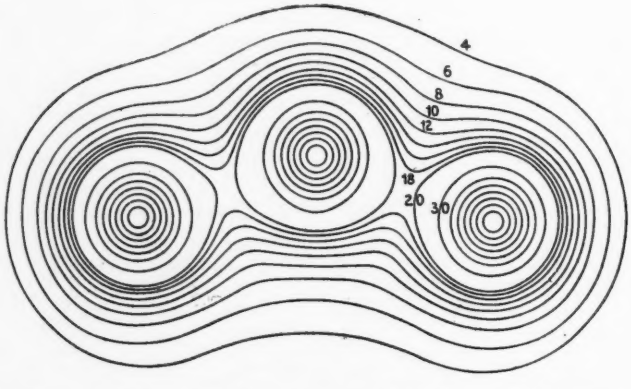


FIG. 19.—Contours or iso-lux curves for three lights. Derived from Fig. 18.

Fig. 19 gives the contours for three lamps in zig-zag, being the contours of Fig. 18 compounded by the tracing paper method with those of a third lamp.

full-line curves in Fig. 12 represented a vertical section along the middle line of Fig. 17.

The contour lines for three lamps, placed at the corners of an equilateral triangle, the side of which is 1·5 the height of the lamp above the ground, maxima are not under the lamps, and that within the triangle the light does not vary more than 10 per cent. In most cases of street lighting the

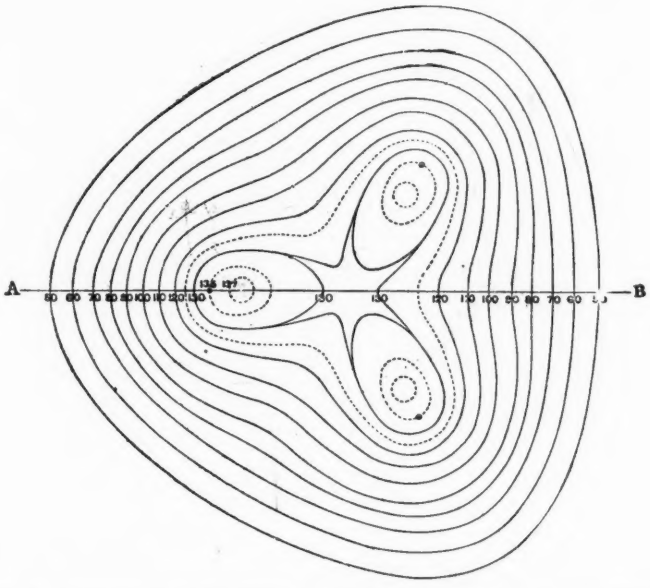


FIG. 20.—Contours or iso-lux curves due to three lights at distances apart equal to one and a half times their height.

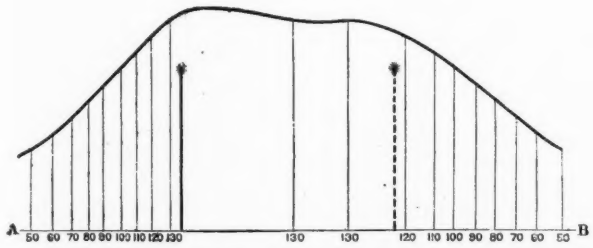


FIG. 21.—Illumination curve due to three lights at distances apart equal to one and a half times their height, being a section of Fig. 20 through the line AB.

are given in Fig. 20. Treating this as a solid figure, Fig. 21, a curve of the same kind as Figs. 10 to 13, is a section of it through the line A B. It is to be noticed that the points of contours are little else but circles; the other curves are negligible, since they would refer to differences of illumination which are too small to be of any practical importance.

With ordinary arc lamps in clear glass lanterns or globes the contour lines present a very different character, owing to the peculiar distribution of at a distance apart equal to 1·5 of their height. Fig. 23 represents a section through Fig. 22. Fig. 24 shows the contour lines for three arc lamps

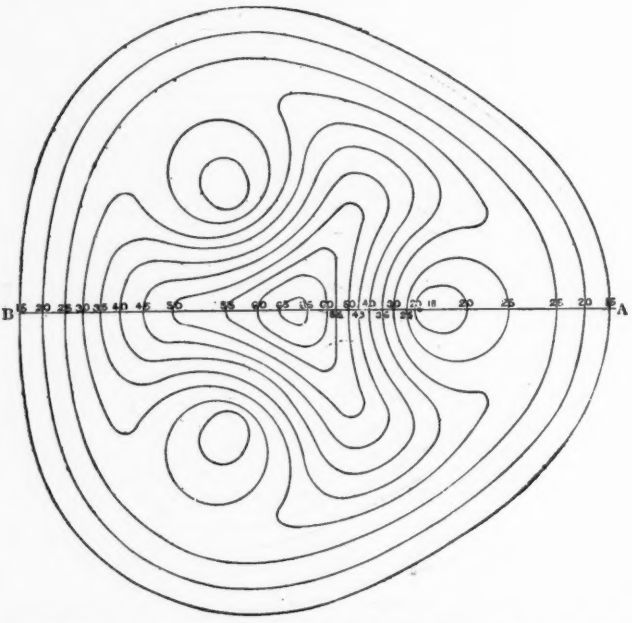


FIG. 22.—Contours or iso-lux curves due to three arc lamps at distances apart equal to one and a half times their height.

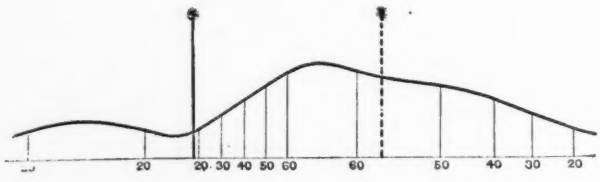


FIG. 23.—Illumination curve along the line AB, Fig. 22.

the light. The contour lines in Figs. 22 and 24 have been constructed on the assumption that the light is distributed as shown in Fig. 14. Fig. 22 represents the illumination due to three arc lamps placed at a distance apart equal to three times their height; and Fig. 25 is a section through A B, Fig. 24. The values given for the illumination at each contour are arbitrary, but do not

differ much from the values given in Fig. 14.

With modern flame arcs, or with diffusing globes or lanterns, the distribution would, of course, resemble Fig. 9 rather than Fig. 14.

It is not suggested that the construction of these contour lines should often be carried out, and no great importance is attached to them. The study of a few typical cases is interesting. Many such curves may be found in H. Maréchal's book, 'L'Eclairage à Paris.' André Blondel and F. Uppenborn have produced others, some of them being highly complicated.

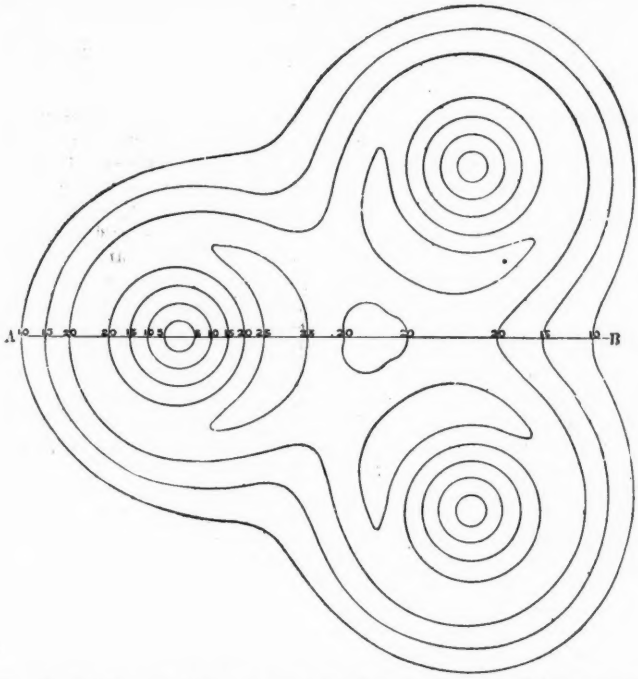


FIG. 24.—Contours or iso-lux curves due to three arc lamps at distances apart equal to three times their height.

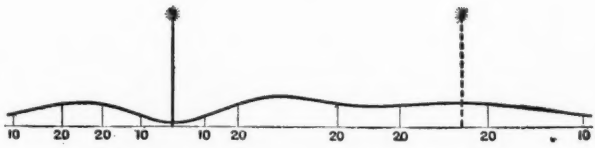


FIG. 25.—Illumination curve along the line AB, Fig. 24.

(To be continued.)

Some General Notes on Artificial Illumination.

By Norton H. Humphrys, Assoc. M.Inst.C.E. F.C.S.

It has been my practice for the last twenty-five years or more to take a stroll once or twice a year round the principal streets and districts in the West-End of London after dark, under the impression that some of the best examples of the latest applications of artificial lighting may be seen there, and to make observations from the point of view that might be expected to be held by a lighting or illuminating engineer. Such an individual may be supposed to look for a maximum of efficiency at a minimum of cost. He would wish to avoid waste in every form on the one hand, and to secure a satisfactory degree of efficiency on the other. In the course of the period above named there has been, according to the opinion of the man in the street, a great "improvement." He will tell you that the shops and the streets are "better" lit than they used to be, which simply means that there are more light centres and higher candle-power, but not necessarily that there is any advance from my point of view. I say that the lighting is worse, in the sense that there is more waste, more unequal diffusion, and less consideration for the few elementary principles that we know to be necessary for efficient lighting. In my notes I refer to the light centre or source as "the light," and to the objects to be lighted as "the object," and it will be convenient to retain these terms. We must also remember, in connexion with this subject, the primary purpose for which the light is provided. A street lamp is intended to act as a guide and a help to passengers, a lamp in a shop-window to show off goods, and so on.

We are not at present interested in the description of light, but only with its candle-power. It may be electric, arc or glow, gas, incandescent or open flame, petroleum, or any medium in actual use. But we must avoid the mistake of figuring upon candle-power as being equivalent to money value. The actual cost, even with the same medium does not vary *pro rata*. For various reasons that do not now concern us, the cost of a 200 candle-power light is not necessarily twice that of a 100 candle-power. Nor has the practical value or benefit derived by the user anything more than a very indirect connexion with candle-power. It is affected by the colour, the shape, the area, and the diffusive power, and especially by the extent of the spherical area covered by the light. The burner and the branch or other support must necessarily block out a part of the lighting effect, and the extent and position of the part so stopped will exercise an important effect on the value of the light. A light is also considerably influenced by the nature, and especially by the colour, of its surroundings. In the case of a light of equal candle-power, very different effects are produced (1) when it is placed in a window stocked with white goods; (2) amidst a pile of black goods; (3) surrounded by brilliantly-polished articles, such as jewellery, &c.

In primitive days, from an illuminating standpoint, there was no idea of anything like a broad general effect, but the candle was placed as closely as circumstances would permit to the work or the object. The remainder of the compartment might be in comparative darkness. Even in a shop the lights were confined to the counter. This kind of lighting is now replaced by a more or less equable lighting of the whole area of the room, building, or street. But it is remarkable how deeply rooted old ideas and customs

seem to be, and how they retain a hold long after the cause which originated them has disappeared. Even in modern designs there is a tendency to retain the candle-holder or the oil reservoir in the pattern, and the same appears to be the case with regard to the custom of placing the candle or the lamp close at one's elbow. So long as we are only dealing with lights of less than 10 candle-power there is no objection to placing the light close to the object, but when we use lights that are valued in hundreds or even thousands of candle-power several new conditions come in.

Probably the first impression that strikes the thoughtful observer is the *waste* of light, as represented by powerful lights hanging so low as almost to swing in one's face, or placed within a yard of the object. It seems hackneyed to say that the eye should rest upon the object and not on the light; but in practice the lights seem to push forward into the front place. They are located obtrusively on the fronts of buildings, in front of the object, and in other positions where they are bound to be looked at, and where they exercise no useful effect. Why a tradesman should imagine that the public will have a better opinion of his wares or resort more frequently to his establishment because he strains their eyesight and offends their innate sense of the fitness of things by the extravagant and senseless use of light, is not very obvious. Yet there appears to be a widespread impression that moths are not the only things that are attracted by a dazzling light.

There are other considerations even more important than the waste of light and the waste of money. I am glad to see that some attention is being directed to the relation of artificial light to the human eyesight. Many people are engaged for half their working time or more under artificial conditions of lighting, and all are concerned in the matter to an important degree. The way in which 1,000 to 2,000 candle-power lights are used, to say the least, displays very great confidence in the power of the eye to adjust itself to very wide variations. But the eye must be subject to limitations, just like the other senses. The ear, for example, can recognize only a limited number of octaves, as regards sound, and the eye also has its high and its low limit, with no sharp line of demarcation. Suppose we are seeking to note the details of a large poster or the details of a building by the aid of a variable light, such as that afforded by one carried on a motor-car and approaching at a slow rate. At first the light is at such a distance that we cannot see anything. As it approaches nearer and nearer, the details sought for become gradually more and more distinct, until at last there is sufficient light to render the observation easy and comfortable. Assuming the intensity of the light to continue increasing beyond this point, a stage is reached when, to use the common expression, it becomes dazzling or blinding. And if we allow our investigations of the public lighting to extend over some hours, we find by unpleasant experience that a long-continued glaring light is not beneficial to the eyesight. The power of the eye to adjust itself to the lighting surroundings covers considerable limits, between the point when we say that it is too dark to see, and that the light is too bright. But is it safe to assume that any dangerous or prejudicial overtaxing of this power will at once be evidenced by fatigue or other physical discomfort? It does not seem unreasonable to assume that continued or frequent contact with unnecessarily high power lights must tend to weaken or depress the powers of vision. The importance of this is evident when we remember that the majority of workers depend upon eyesight as an indispensable assistant in their daily work, and would be helpless without it.

A rule that was accepted and followed in practice for many years was that a safe, sufficient, and comfortable illumination is afforded by the candle-foot, a light equivalent to that afforded by one standard candle placed at a distance of one foot from the object. The value of this degree of light can be shown on an ordinary photometer, which can readily be made to show one, two,

or more candle-feet upon the screen. One or two candle-feet power does not strain or fatigue the eye, but when we get up to ten or more candle-feet the eye is fatigued. Following the rule of the candle-foot I have, in the course of several years, carried out several installations of lighting that were accepted and pronounced to be satisfactory. According to the laws of inverse squares, the distance between the light and object to secure the candle-foot should be as follows :—

C.P.		Feet.	C.P.		Feet.
2,000	...	45	100	...	10
1,000	...	31¼	80	...	9
500	...	22	50	...	7
300	...	17	40	...	6
200	...	14	30	...	5½
150	...	12	20	...	4½

Before proceeding to notice conclusions that this table naturally suggests, it will be desirable to glance at one or two other details. The question of angle with the line of sight is quite as important, if not more so, than that of distance. The line of sight is a straight line drawn from the eye of the observer to the object, and obviously may cover any point of the circle or sphere to which the eye can be directed. While walking or sitting in a natural position the line of sight tends to keep in the vicinity of a horizontal direction, and the horizontal may be called the natural line of sight. If we consider daylight, of the actual reality of which the illuminating engineer can produce but a more or less imperfect imitation, we find that the lighting angle is large. The protection afforded by the projecting eyebrow is an indication of the fact that the lighting angle should be not far short of 90 degrees But our practical observations carry the impression that the question of lighting-angle is neglected as much as that of distance, and frequently it is much too small.

As a matter of general experience the difficulty of adopting the powers of vision to suit either a dazzling or a dim light is greatly increased if there is also a small lighting-angle.

So far we have been considering properties inherent to the light itself, but the object and its surroundings have an important effect. We have to consider the effects of colour and of reflecting power, and this is especially important as regards the antipodes, the opposite sides of the light. We sit at a table to write or to read with a light, say, 4 ft. above, and provided with no downward reflector. Under these circumstances the lighting effect will be influenced by the character of the ceiling, whether the usual white plaster or wood of various kinds. The colour of the walls and furniture also figure in the matter, but not to such an extent as the ceiling. In the street, note the different effect of the street lamps (*a*) in the vicinity of a clean white stone building, and (*b*) where there are trees or open space behind them. If we can find a white goods shop, a jeweller's, and a boot shop, each lighted by an equal or nearly equal candle-power, we can notice the different effect in each case.

But it would appear that, as a rule, the lighting arrangements are decided in a haphazard sort of way, without any reference to the three important considerations—distance, angle, and environment—as above noticed. There is a story told of a nigger who went into a shop and ordered a pair of boots. When asked to allow the measure of his foot to be taken, he replied to the effect that he did not trouble about that, but would like them as large as possible for the price. Many things are purchased, however, on identical lines, light amongst the number. The power, position, and number of the lights are oftener a matter of mere selection from designs in an illustrated list than of a competent estimate or scheme for producing a predetermined effect.

The power of each light centre should be limited according to the height of the room or apartment as determining the distance between the light and the object; and in rooms with white ceilings a satisfactory result is usually produced when they are situated at about two-thirds of the distance between the floor and the ceiling. To give an example, in a room 12 ft. high, the lights should be 8 or 9 ft. from the floor, and should not ex-

ceed 40 to 50 candle-power. In most cases it will be found that the light must be not more than 10 ft. from the object, and therefore it is not too much to say that lights of less than 200 candle-power are sufficient for all ordinary purposes, and, indeed, for anything short of what is known in America as mast-lighting. But I would suggest that the limitations as to the distance, the angle, and the surroundings are affected by the candle-power, and that in regard to any particular degree, whether 50, 100, 200, or 500 candle, there are special conditions suited to each.

A consideration of the distance table above quoted seems to show that there is a tendency towards lights of higher power than are actually necessary, and this leads up to the question of the most appropriate size for the light unit. Until within comparatively recent times this was almost a matter of Hobson's choice. It was not a question of what size was wanted, but of what size could be had. For some reason or other not connected in any way with illumination, the 5 candle-feet per hour gas-burner acquired a leading position, and at one time represented more than half of the total consumption of gas. The same thing occurred with the 16 candle-power electric glow-lamp. But it is now possible to get a range of almost anything between 5 and 200 candles, so there is no longer any excuse for a slavish imitation or preference for any one special size. An important feature to be considered is the area occupied by the light. In theory we assume the light to emanate from one point, but in practice the light always has an appreciable area. All other things being equal it is preferable that the area should be large. Given an equal photometrical value, a light of, say, 4 square inches in area is preferable to one the size of a pea. The smaller area gives sharp shadows and a greater intensity per unit of area. Shadows are always objectionable, and the object of skilful lighting is to neutralize them, or, at any rate, to tone them down. The larger the light area the less sharp will be the shadows, and, therefore, the less noticeable. And since the eye objects to violent contrasts, the lower the intensity the more satisfactory the effect. This is the reason why translucent or "opal" globes are preferred for lights of small area but high intensity. In place of a dazzling point of light, we get a luminous globe of several inches in diameter. There is a large loss of photometrical value, perhaps two-thirds. But the light is pronounced to be better than before.

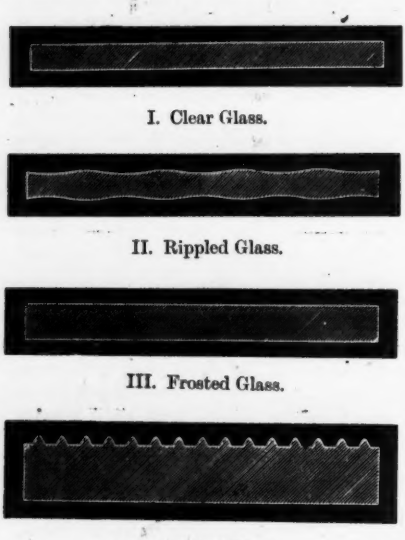
We can considerably alter the effect of objectionable features by the judicious use of globes, shades, or reflectors. By the term "globe" we may understand an arrangement that entirely encloses, and possibly conceals, the true shape of the light centre. A "shade" is usually placed above the light, to deflect a portion that would otherwise be wasted on the ceiling or upper part of the room into a useful direction. A reflector is an opaque shade that need not necessarily be above the light. We can find plenty of examples of globes and shades. A white opal shade above the light is very generally used, but as is the case with the other fittings, the shape appears to be a matter of fanciful selection rather than of predetermined effect. Some recent researches seem to show that the angle of the shade, as compared with the line of vision, might well be a matter of careful investigation and experiment. The same applies to reflectors, the most familiar examples of which are the cardboard shades placed over billiard lights or the desks in a bank or counting-house. One of the most interesting examples of reflectors is the footlights at a theatre, where they not only direct the light to the object, but conceal the light centre. It is by following these lines that the best lighting effects are produced. The concealment of the light is only practicable in particular cases, but much can be done in this direction by keeping the light as far as possible out of the prevalent lines of vision, and by the use of globes and reflectors.

Window-panes and Daylight Illumination.

By Dr. Berthold Monasch.

Window-panes serve the double purpose of allowing light and air to enter a dwelling-room.

The entrance of air can, of course, easily be regulated at will, according to the temperature of the room and the climatic conditions generally; the entrance of daylight, on the other hand, depends both upon the brightness of the sky for the time being, and also upon the variety of glass of which the window-pane is composed. Whereas the alterations in illumination that may occur in the case of artificial lighting have been the subject of much careful investigation, the intensity of daylight-illumination entering by the window has only rarely received similar attention.



I. Clear Glass.

II. Rippled Glass.

III. Frosted Glass.

IV. Ribbed Glass.

Fig. 1.

In what follows it is proposed to devote closer attention to the variations that may occur in illumination of this nature.

As a general rule, plane-parallel panes of clear glass are utilized for windows; clear glass is naturally adopted for the most economical use of daylight conditions, on account of its relatively small absorption of light. Glass of this nature, however, fulfils a second purpose. Window-panes are intended not only to allow the daylight to enter the room, but also to enable those within to see what is going on outside. The effect of blinds, curtains, and other decorative and absorbing media, in obstructing the entrance of light or the view of those within the room, cannot easily be made a subject of scientific measurement; in such cases æsthetic considerations, which can naturally only be satisfied by a certain loss as regards optical efficiency, enter into the problem. But daylight illumination is in general so powerful that such a reduction in efficiency can be readily sanctioned, on account of the resulting improvement in convenience and comfort.

There are also circumstances under which it is desirable that windows should not be transparent—for instance, in the case of rooms on a level with the street, or in factories in which secret processes are carried out. Then, again, it may also be considered undesirable for those within a room to be able to see out through the windows; some people, for instance, maintain that their employés do less work when they are able to gaze out on the blue sky and green meadows.

Windows are generally obscured by the use of clouded or frosted glass, which have the property of obstructing the direct passage of the rays of light causing them to be diffusely distributed. In spite of the apparent unkindness of preventing the eye from dwelling upon the fair prospect without, this method presents the advantage of preventing the eyes from being dazzled by sudden

alterations in the brightness of daylight illumination. In private dwelling-rooms one might, of course, employ curtains under these circumstances. In workshops, where economy must be practised, there are as a rule no curtains, and in any case they would usually accumulate too much dust and involve the expense of frequent cleaning.

In order to render windows opaque as regards the perception of external objects, and yet transparent to light, one must endeavour to reduce the loss through absorption which accompanies the use of frosted glass; with this object in view, clear glass of a cut or rippled nature may be employed. Cut glass, however, presents the disadvantage of being liable to collect dust in its crevices, and of being in addition, exceedingly inconvenient to clean. Rippled glasses keep clean very much longer, but exhibit maxima and minima in the transmitted illumination. They are also open to the further objection that any moving object behind them gives rise to an unpleasant flickering appearance. This effect may, for instance, be caused by any one passing the window.

For the purpose of studying the qualities of these various kinds of glass, an example of each was selected; the cross-sectional appearance of each of the four types is shown in Fig. 1.

I. represents a plane parallel clear-glass pane, 2·2 mm. thick.

II. represents a rippled clear-glass pane.

III. represents a frosted plane parallel glass pane 3 mm. in thickness. This was originally a sheet of clear glass, but was frosted over on one side by means of a sand-blast.

IV. represents a clear sheet of ribbed glass, 5 mm. in thickness up to the base of the ribs. The ribs themselves are 0·75 mm. in height, and run parallel over the surface of the glass at a distance apart of 2 mm.

Measurements of Intensity of Transmitted Light.

Experiments were first made with the object of observing the modifications in the nature of rays of light during their passage through the glass. The vertical filament of a 220 volt

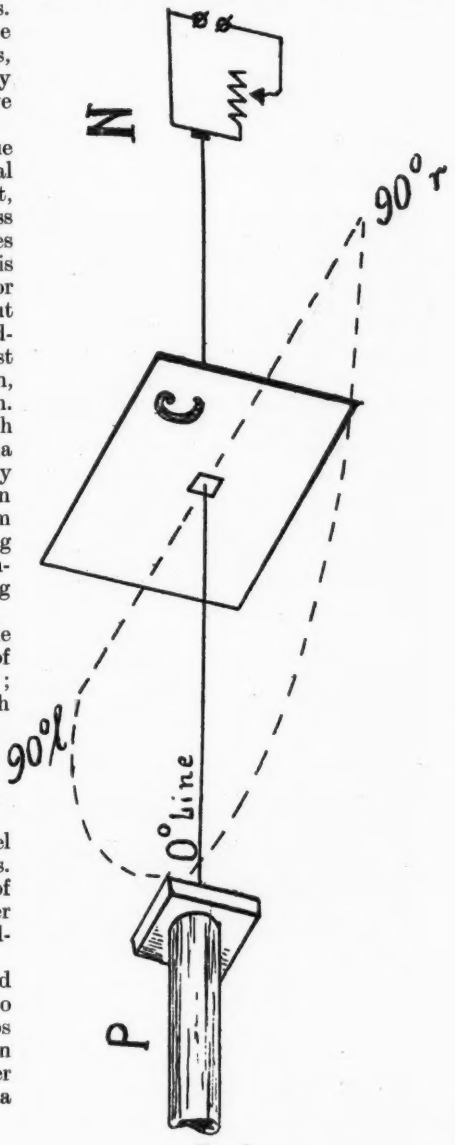


Fig. 2.

Nernst lamp was utilized as a source of light, the rays being focussed into a parallel beam by the usual optical

arrangements. This filament is represented by N in Fig. 2.

The circuit of the Nernst lamp was provided with an adjustable rheostat, so that the candle-power of the lamp might be retained constant throughout the experiments. The beam of light impinged upon a cardboard screen C, pierced with an aperture one square centimetre in section. The photometer P was so placed as to face the middle ray passing through this aperture. This direction will be described as 0°. The photometer was of the well-known Weber type equipped with the Lummer-Brodhun prism arrangement; a tungsten lamp served as the source of comparison.

If, therefore, the photometer is situated on the 0° line, it is easy to determine the amount of light absorbed by the various types of glass referred to. All that is necessary is to measure the intensity of the light coming through the aperture when there is no glass in front of it, and then to interpose the sheet of glass to be examined, and repeat the measurement.

In this way the results shown in the following table were obtained.

Variety of Glass.	Intensity of light with no glass plate.	Intensity of light with glass plate.	Percentage loss of light along the line 0°.
——	24·5 H.K.	——	0 per cent.
Clear Glass I.	,,	21·1 H.K.	9·8 ,,
Rippled Glass II. ...	,,	4·65 ,,	81·0 ,, max. 73·5 ,, min.
Frosted Glass III. ...	,,	0·60 ,,	97·5 ,,
Ribbed Glass IV. ...	,,	1·67 ,,	93·0 ,,

A mere knowledge of the light absorbed in the direction of the 0° line, however, by no means yields us all the information that is essential in order to judge the qualities of the specimen of glass under examination. With the exception of the clear plane-parallel glass, all these specimens alter the distribution and diffuse the light of the parallel beam. Therefore the distribution-curves of the light emerging through each of the specimens in a horizontal plane drawn through the line 0° as axis was studied.

In Fig. 3, in which the results obtained when no glass of any kind was placed in front of the aperture are shown, no light emerges on either side of the zero-line, except that yielded by the parallel beam of light itself. Hence we merely obtain the single measurement shown by the point on the diagram surrounded by the small circle, corresponding to the intensity of the light passing through the aperture.

Fig. 4 illustrates the corresponding condition of affairs when the sheet of clear glass was placed in front of the orifice. We again obtain practically no diffusion, and practically the same figure as in the previous case, the only difference being that the intensity is reduced by absorption to only 22·1 H.K. instead of 24·5; the encircled point is therefore merely brought a little nearer the origin. In the case of the other glasses the light is diffused. Figs. 5, 6, and 7, correspond to the ribbed glass IV., the frosted glass III., and the rippled glass II. respectively.

The most uniform diffusion occurs in Fig. 6, the angle over which a measureable illumination in a horizontal plane exists being as much as 20°. In the case of the ribbed glass (Fig. 5) this range amounted to 35°, but the distribution of light was not so uniform as in the previous case. During these measurements the sheet of glass was so placed that the ribbed lines ran a vertical course, *i.e.*, perpendicular to the plane of measurement. The rippled glass also diffused the light, but only over 6°—a narrower region than in the case of glasses III. and IV. The loss of illumination in the 0° direction is, however, very small.

The curved surface of this glass gives rise to very irregular diffusion, distinct maxima and minima being distinguishable, and in contradistinction to

all the other cases, the greatest illumination in this instance does not occur along the direction-line 0°. This, however, naturally depends upon the position of the piece of glass covering the aperture; by altering this position either a maximum or a minimum can be obtained.

MEASUREMENTS OF ILLUMINATION.

In order to study these different specimens under more practical conditions, some measurements of illumination were carried out in a room, the window of which could be occupied by sheets of either of the glasses to be examined. For the purpose of these experiments the Martens photometer was utilized, measurements being made in a horizontal plane, at a height of one meter above the floor. The walls and ceiling of the room were coated with a material yielding a dead-black surface, the only source of illumination being a window 35 centimetres square. In this aperture the various glasses were introduced in turn. This window is shown in plan and outline in Fig. 8.

The measurements took place firstly along the line *a*, which is parallel to, and 50 centimetres distant from the window, and secondly along the parallel line *b*, which is situated at a distance of one metre. Both these lines lie in a horizontal plane through the lower ledge of the window. The small circles, occurring at intervals of 10 centimetres, indicate the points at which measurements were made. The measurements along the line *a* could not be extended any further to the right, as this would have brought the instrument into the shadow of the wall.

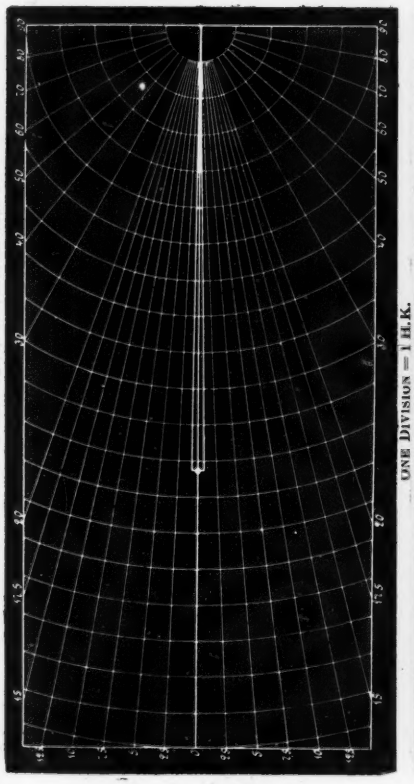


FIG. 3.—No Glass.

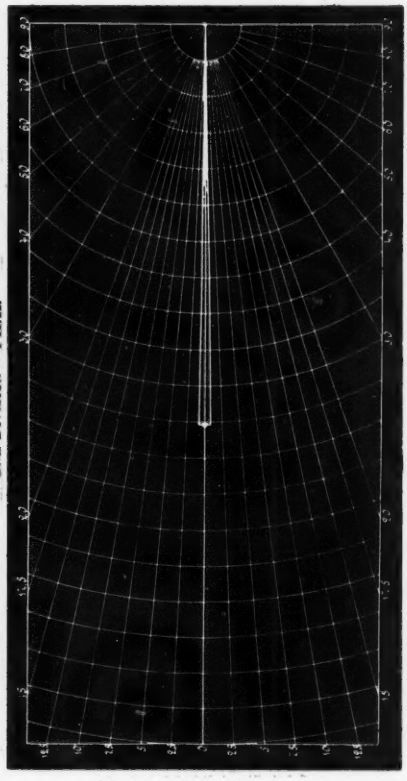


FIG. 4.—Clear Glass.

The intensity of illumination throughout the day varies very greatly when afforded by intermittent sunshine or an irregularly clouded sky; for this reason a dull cloudy day during the month of February, 1908, on which the sky as a whole presented a uniform grey tint, was selected for these experiments. Before and after each measurement, the window pane was removed and the value of the illumination at the first left point of reference in the line *a* tested. In this way it was possible to form an idea of the fluctuation in brightness that were likely to occur in the course of the experiments. The following are the greatest variations recorded obtained, as described, with the open window :—

Plate of clear glass, 89–102 lux.
„ „ ribbed „ 76– 80 „
„ „ rippled „ 80– 81 „
„ „ frosted „ 89– 90 „

During the measurements with the plate of clear glass, the illumination was somewhat greater than in the other cases. The curve shown in Fig. 9, illustrating the results of this experiment, along the line *a*, shows that the most intense illumination extended across the breadth of the window, and then gradually fell away to zero. The bending of the curve of illumination for the point furthest to the left along the line *a* arises from the obstruction caused by the central opaque support of the window-pane. It is evident how much weaker, and at the same time how

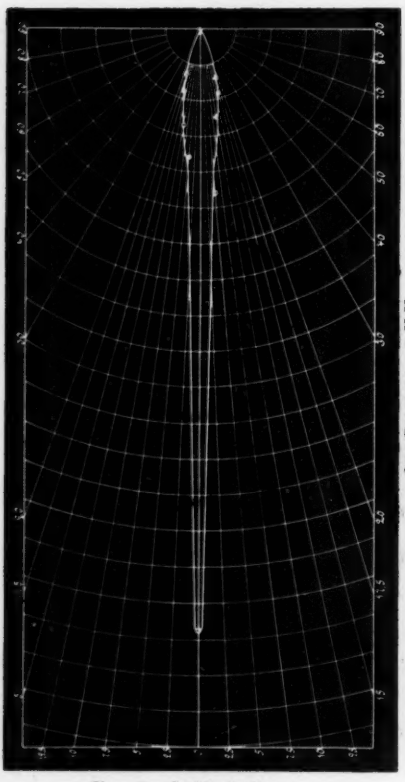


Fig. 5.—Rubbed Glass.

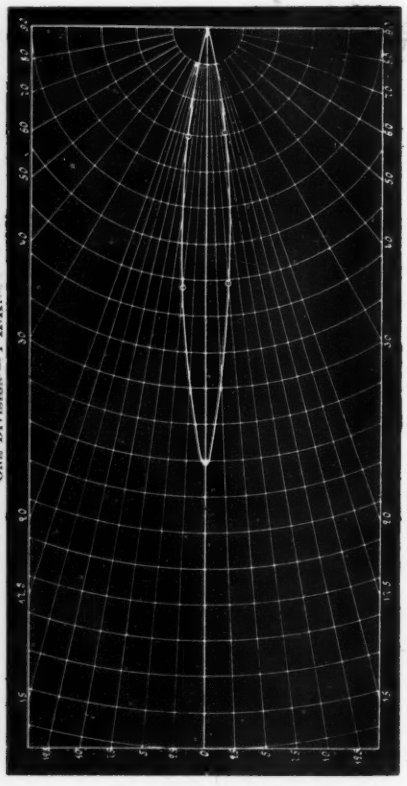


Fig. 6.—Frosted Glass.

ONE DIVISION = 1 H.K.

much more uniform, is the illumination along the line *b*.

Figs 10, 11, and 12 represent the corresponding results in the case of the ribbed, frosted, and rippled glass respectively. During these measurements the frosted side of the glass III. and the ribbed side of the glass IV. were presented to the light.

which it is composed, but must also be ascribed to the presence of dirt, which cannot be entirely avoided after glass of this kind has been in use for a short time — at least not without the help of cleaning apparatus which is not likely to be used under practical conditions.

The marked maximum which occurs

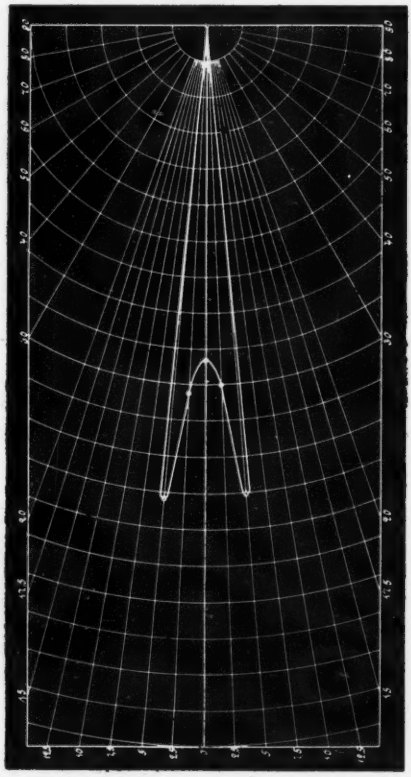


FIG. 7.—Rippled Glass. One division=1 H.K.

From a comparison of Figs. 10 and 11 it may be seen that the frosted glass clearly absorbs a greater amount of light than the others, but is more effective in diffusing the light, thus giving rise to a uniform degree of illumination. The want of uniformity in the illumination obtained in the case of the ribbed glass, may be partially due to the irregular nature of the ridges of

at the point of measurement abscissa 20 in the case of the curve of illumination obtained with the rippled specimen (Fig. 12) may be ascribed to the lens-action of the ripples on the surface of the glass.

The results of measurements of illumination in a blackened room represent what occurs in an extreme case. On the one hand it may be

remarked that the general course of the curves of illumination will be unaffected by the light reflected from neighbouring walls, &c. On the other hand the individual readings will be appreciably lower, in the case of a blackened interior, than those which would be obtained under otherwise similar conditions, in a room provided with the usual light-coloured walls and ceiling.

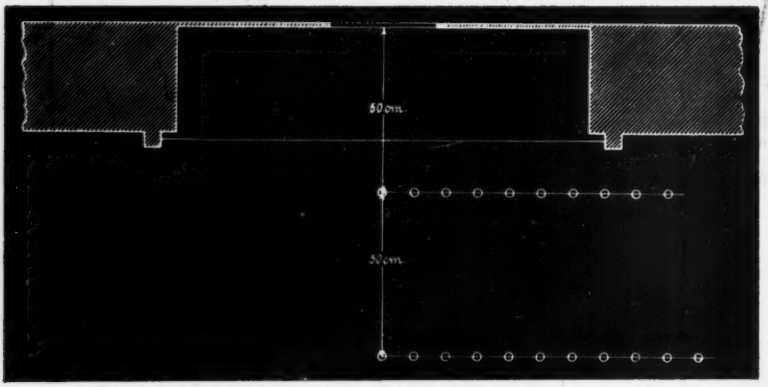


FIG. 8.—Plan of Window. Upper line *a*. Lower line *b*.

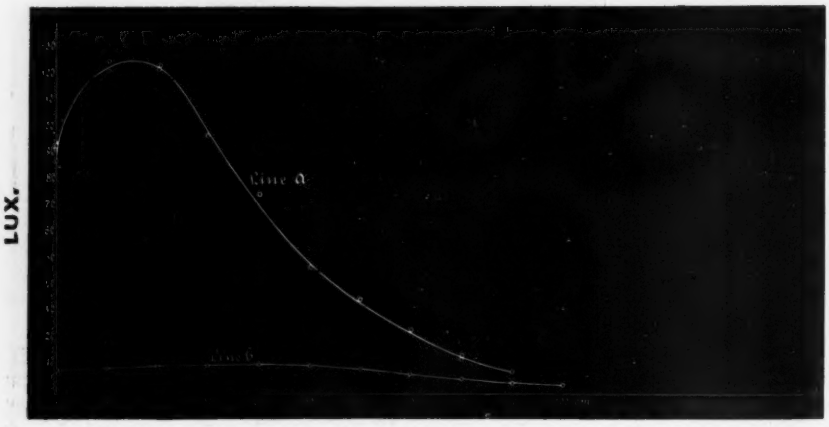


FIG. 9.—Clear glass.

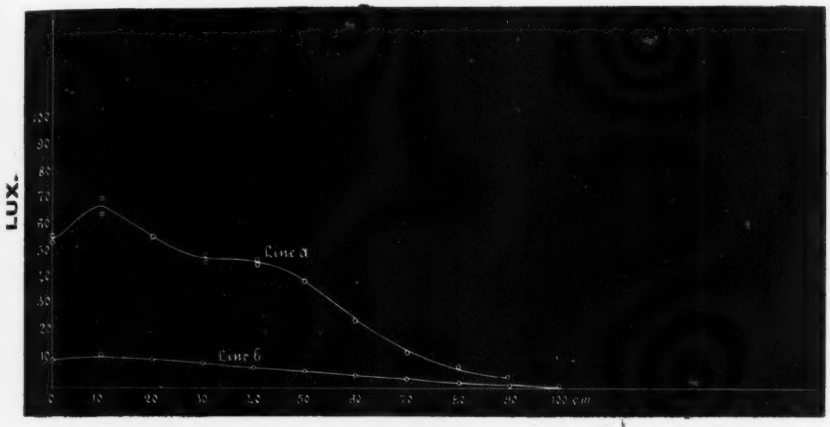


FIG. 10.

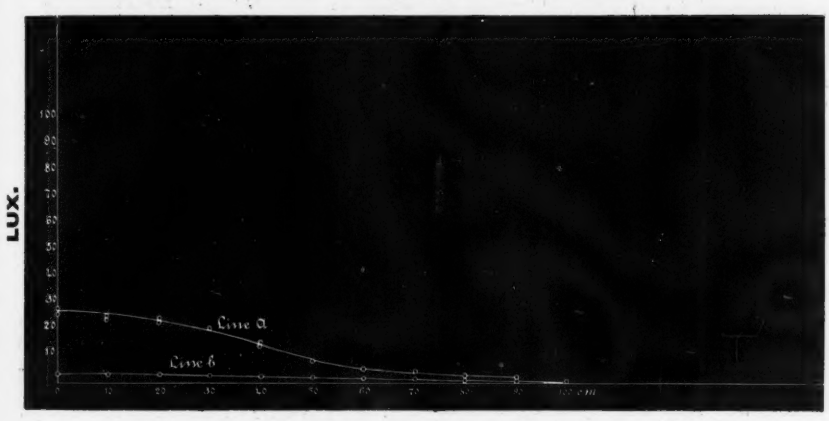


FIG. 11.—Frosted Glass.

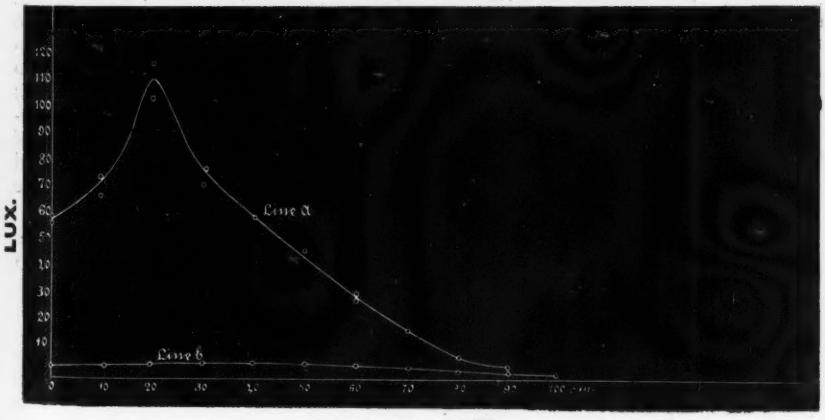


FIG. 12.—Rippled Glass.

The Production and Utilization of Light.

Luminous Efficiency and the Mechanical Equivalent of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 296.)

From the commencement of quantitative work in connexion with radiation, attempts have been made to determine the fraction of the total power or radiation of a luminous source which is given out as light. As early as 1833 Melloni, in the course of his classical studies of radiation, is stated to have made a measurement of the total radiation from a lamp and of that portion transmitted through a transparent plate of crystallized alum which was assumed to be light. Tyndall in 1862 improved on this process, and made several experiments at the Royal Institution on gas flames and the electric arc. He also employed another method in which a spectrum of a source of light was formed, and the distribution of energy for various portions of the spectrum obtained by a thermopile. The efficiency was then deduced from the area of the curve between the limits of the spectrum, compared with the total area. This method has been since developed by Langley to a remarkable extent.

One other method remains to be described, that of the calorimeter, which was first employed by Merritt of Cornell, although attempts had previously been made by Blattner in 1886, and by Staub. In this method the source of light is immersed in a glass vessel containing water, and the amount of heat given to the water is measured when the light escapes, and when it is prevented from escaping by blackening the lamp bulb.

Before going into details of the work and results of various investigators, a few words must be said as to the meaning of the term luminous efficiency, and as to the *rationale* of the three methods above indicated. All sources of light require a supply of power, which power is dissipated as heat and light, as follows :—

- Total power (Q)
  - Conduction (through supports, &c.)
  - Convection (air currents)
  - Total radiation (R)
    - infra-red—"dark heat"
    - visible—light (L)
    - ultra-violet—"chemical rays"

It is obvious, therefore, that the practical meaning of luminous efficiency should be that fraction of the total power which is given out in the form of light, or $\frac{L}{Q}$. In the majority of experiments, however, this fraction is not directly determined, but an attempt is made to find the fraction of the total *radiation*, which is given out in the form of light, or $\frac{L}{R}$. To remove the confusion which has existed between these two fractions, Prof. Nichols of Cornell has proposed the terms "total efficiency" for the former, and "radiant efficiency" for the latter, so that we have—

$$\text{Total efficiency} \quad \eta = \frac{L}{Q}$$

$$\text{Radiant efficiency} \quad \eta_R = \frac{L}{R}$$

To obtain the total efficiency from the radiant efficiency, therefore, it is necessary to multiply by the fraction $\frac{R}{Q}$. In the case of electric glow lamps, nearly the whole of the power is radiated, as there is no air in contact with the filament, and the supports of the filament are too thin to conduct much; so that the total and radiant efficiencies are not very different. With combustion, however, a very large amount of convection always takes place, and hence the radiation may not be more than a fifth of the total power.

A further difficulty yet remains, however. The quantities R or Q are perfectly definite in meaning, and can usually be measured with fair accuracy. But the power in the form of light, L, is simply that part of the radiation which affects the retina of the eye, and consequently requires to be taken between the limits of the

visible spectrum. These limits are generally taken as between wave-lengths of ·38 and ·76 μ ($1\mu = \cdot001$ mm.). But even assuming these limits to be definitely known and invariable, we are not dealing with one kind of light, but with all the colours from red to violet, and the visual value or luminosity of these colours is very different. We are therefore confronted with the difficulty that if we define the total efficiency as $\frac{L}{Q}$, all sources having the same values of L and Q would have the same efficiency, while if one of these sources were of a yellow colour and another of a blue or violet colour, their illuminating powers would be very different.

To obviate this difficulty Prof. C. Féry and Dr. C. Guilleaume in France have made propositions which are equivalent in meaning. Instead of taking the total power of the source between the spectral limits, it is proposed to substitute the amount of power required to produce the same luminous effect as the source, in light of a definite character, and this light is the yellow-green light corresponding to the wave length ·54 μ which appears from various experiments to be the light which gives the maximum visible effect for a given amount of power. Unless, therefore, the source emits this kind of light, there will be an amount of power L_λ less than L which will give the same luminous intensity as the source in the form of yellow-green light. The present writer has proposed to call the fraction $\eta_\lambda = \frac{L_\lambda}{Q}$ the "reduced" luminous efficiency as it is reduced to light of a standard colour, and although this mode of reckoning luminous efficiency is open to some criticism, it appears to be more definite in meaning and of greater practical value than any other.

This leads us finally, therefore, to a very simple and definite method of determining luminous efficiencies. Instead of finding out the amount of power contained in the light to be tested, we have to find the amount of power required to give the same intensity in yellow-green light. But this means obviously that if we can determine once for all the amount of power to give one mean spherical candle-power of yellow-green light, it will only be necessary to find the power in watts per candle for the source to be tested, by ordinary photometric methods. The total luminous efficiency of the source will then be obtained by dividing the power in watts per candle for the yellow-green light, by the power in watts per candle for the source.

This quantity—the power per mean spherical candle-power of some standard light—is what may be called the mechanical equivalent of light. Hitherto this term has been applied to the power required to produce a mean spherical candle of white light, but this is very indefinite for the reasons above stated, and it would therefore probably be better to restrict it to that required for a mean spherical candle-power of monochromatic light of maximum luminosity. The advantages of this are, firstly, that it is only necessary to fix one quantity, the wave-length of the standard light, which appears to be more or less definitely settled as ·54μ; and, secondly, that as this is taken as the wave-length of maximum luminosity small variations in the purity or wave-length of the light are without great influence on the result.*

With these preliminary remarks we may pass to the experimental methods and results. It will be seen that there are four methods by which luminous efficiencies may be determined.

A. Thermopile or other detector of radiation with absorbing screens (radiant efficiency).

B—Calorimetric measurement with clear and obscured lamp (total efficiency).

C—Measurement of the distribution of power along the spectrum (radiant efficiency).

D—Comparison of power consumption, with the mechanical equivalent of light (reduced total efficiency).

* It is probable, however, that this figure depends to a certain extent upon the part of the retina employed in the observations.

A—*Absorbing screen method.*—The method employed by Tyndall in 1862 appears to have been followed almost exactly by later workers. The radiation from the source under test was first allowed to fall on the blackened face of a thermopile, and a deflection, D_1, was obtained on a galvanometer connected to it proportional to the total radiation from the source. A trough of water or alum solution was then interposed and a second deflection, D_2, obtained. If the trough permitted the whole of the light to pass, and cut off all the invisible radiation, we should have the radiant efficiency $\eta_R = \frac{L}{R} = \frac{D_2}{D_1}$

But as a matter of fact the trough absorbs some of the light and transmits some of the "dark heat." The amount of light lost is simply determined by a photometric measurement of the brightness of the source with and without the trough. If a is the co-efficient of transmission of the trough $= \frac{K_2}{K_1}$ where K_2 is the brightness of the lamp with the trough interposed, and K_1 that without it, it is clear that the deflection D_2 should be increased to $\frac{D_2}{a}$ to allow for this absorption.

To determine the amount of "dark heat" passing the water or alum trough Tyndall sought for a substance which, while opaque to light, would transmit heat freely, and he found that a solution of iodine in carbon bisulphide fulfilled these conditions. A second trough containing this solution was then placed behind the first and the deflection D_3 noted, due to the radiation passing both troughs. The corrected value of the radiant efficiency $\eta_R = \frac{D_2 - D_3}{a\ D_1}$ This method was employed by Prof. Julius Thomsen of Copenhagen in 1865,* who determined the radiant and total efficiencies of candles, gas flames, and lamps. He, however, only used a water cell 20 cm. thick, and does not mention any corrections for absorption. By an ingenious method based on Dulong and Petit's experiments he separated the radiation from the total power consumption of the flame, finding that with a sperm candle 1400 calories per minute were consumed, of which 210 calories or about one-seventh was radiation, the remaining six-sevenths being conduction and convection. The radiant efficiency by the absorption method came out at 2·1 per cent., giving 4·4 calories per minute, or approximately 0·3 watt as the power in the form of light, or the mechanical equivalent of the light of one candle.

Tumlirz and Krug* employed the same method as Thomsen, substituting, however, a large air thermometer for the thermopile. Nearly the whole of the work on luminous efficiencies, however, which has been done until quite recently, has been by Prof. Nichols and his associates at Cornell. E. Merritt† in 1888 determined the efficiency of glow-lamps, using the alum and iodine screens, finding it to vary from ·5 to 7 per cent, depending on the voltage. The upper figure was for about 3 watts per candle-power. Nakano‡ and Marks§ next determined the radiant efficiency of the arc-lamp, obtaining values of from 8 to 16 per cent under the best conditions; while Geer‖ found an efficiency of from 41 to 48 per cent for the mercury vapour-lamp. Drew,¶ using a special form of radiometer as detector, measured the luminous efficiency of a vacuum tube and found it to be about 44 per cent;

* "Das Mechanische Aequivalent des Lichtes," Pogg Ann. CXXV. 1865, p. 348.

* 'Die Energie der Warmestrahlung bei der Weissgluth,' *Sitzungsber der Kais Akad. der Wiss. Wien*, xcvii., 1888, abth. IIa, p. 1523.

† 'Some Determinations of the Energy of the Light from Incandescent Lamps,' *Am. Ass. for the Advancement of Science*, Cleveland, Aug., 1888.

‡ 'The Efficiency of the Arc Lamp,' *Trans. A.I.E.E.*, vol. vi. p. 308, May 23rd, 1889.

§ 'Life and Efficiency of Arc Lamp Carbons,' *Trans. A.I.E.E.*, vol. vii. p. 170, May 21st, 1890.

‖ 'Radiant Efficiency of the Arons Mercury Vapour Lamp,' *Elec. World and Engineer*, vol. xl. p. 86, July 19th, 1902.

¶ 'The Luminous Efficiency of Vacuum Tube Radiation,' *Phys. Review*, vol. xvii. p. 321, 1905.

Nichols* himself, however, after a study of the transmitting properties of various solutions in conjunction with Coblentz,† has come to the conclusion that absorption methods of determining luminous efficiencies are fundamentally unreliable. The prevailing belief in the heat-absorbing property of alum solution was shown to be entirely wrong, while, on the other hand, the iodine solution was found to absorb only a limited range of the heat waves, as shown in Fig. 1. He, however, found

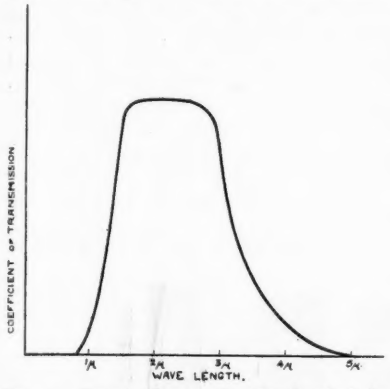


FIG. 1.—Range of wave length absorbed by Iodine Solution.

that a green solution of ferrous-ammonium sulphate $FeSO_4.(NH_4)_2SO_4.6H_2O$ was remarkably opaque to all but luminous radiation; and this solution has been rediscovered in Germany by Russner and by Dr. Lux, whose results appeared in this paper a little while back.

B. *Calorimeter Method.*‡—The arrangement employed by Merritt is typical of this method. The calorimeter consisted of a glass vessel 22 cm. diameter and 38 cm. high, supported on two iron bars so as to allow the light to escape as freely as possible. A continuous stream of water was allowed to flow freely through this vessel, and the temperature of the inflow and outflow water noted, when the lamp was immersed in the calorimeter. The rate of heat production in this case $H_1 = Q - h$, where h is the radiation which escapes in the form of light, &c., while if the lamp is blackened the evolution of heat $H_2 = Q$. If the escaping radiation were the whole of the light we should have $\eta = \frac{L}{Q} = \frac{H_2 - H_1}{H_1}$; but this must be multiplied by a factor $\frac{k}{a}$, where k is the ratio of light to total radiation determined with a thermopile and iodine cell; and a is the proportion of light transmitted, as obtained by a photometer. Merritt obtained results for the total efficiency by this method which were in fairly close argeement with those obtained for the radiant efficiency by the absorbing screen method.

The only other experimenter who has employed the calorimeter method appears to be J. Russner,* who in the early part of last year made some measurements, using the green ferrous ammonium sulphate solution before mentioned. His calorimeter was 10 cm. in diameter and 20 cm. high, and contained 1300 cc. of a 30 per cent solution of the salt, the heat being obtained by the rate of rise of temperature. With this solution he obtained much lower values for the total efficiency than those above given, viz., about 0·6 per cent for the carbon filament lamp, or about one-tenth of Merritt's value. Soon after Mr. Jolley and the present writer experimented with this method, and found that when water was used in the calorimeter, values not far from those of Merritt were obtained, while with the ferrous ammonium sulphate solution extraordinarily low values resulted. In our case, however, it was noticed that the solution decomposed and became turbid during use, giving rise to the idea that chemical action was masking the results. The method was consequently abandoned as unreliable.

* 'A Study of the Transmission Spectra of certain Substances,' *Phys. Review*, vol. i., July-August, 1893; 'Distribution of Energy in the Spectrum of a Glow Lamp,' *Ibid.*, Jan.-Feb., 1905.

† 'On Methods of Measuring Radiant Efficiencies,' *Ibid.*, vol. xvii. p. 302, 1903.

‡ *Loc. cit. ante.*

* 'Über die Licht und Wärmeenergie von Glühlampen,' *Phys. Zeitschr.*, viii. pp. 120-123, Feb. 15th, 1907.

(To be continued.)

Devices for Screening Stray Light from Photometers.

By Dr. Paul Krüss.

One source of error which may considerably influence photometrical readings under certain circumstances, consists in the effects of the diffused light reflected from the walls, floor, and ceiling in the photometer-room, owing to their being illuminated by the source of light under test. In order to reduce this stray light to a minimum the walls and ceilings of such rooms are usually coated with some material giving a dull, black, non-reflecting surface. One also endeavours to secure that the dimensions of the room are sufficiently great to enable the photometer to be at least one metre distant from these surfaces. For the same reason it is preferable not to mount the photometer-bench upon a table offering an extended reflecting surface, but upon suitable isolated supports.

In spite of these precautions it is not infrequently found, particularly in the photometry of very powerful sources of light, that results are obtained which deviate very considerably from the true value. Dr. H. Krüss has already described in the *Journal für Gasbeleuchtung* several sets of experimental results which clearly indicate how great errors of this nature may be, when photometry is carried out without any systematic method of screening from stray light being adopted.

One well-known method of avoiding the influence of such stray light consists in the use of a number of suitable screens, covered with black velvet, and placed at intervals along the photometrical bench. These are, of course, provided with apertures for the benefit of the beam of light, the intensity of which is to be tested, as shown in Fig. 1.

These apertures can be so adjusted as to limit the passage of this beam to as narrow a region as possible without actually interfering with photometric measurement by cutting off some of the light from the photometer. The size of these screens, however, necessarily renders them somewhat inconvenient, especially when, owing to the difference in brilliancy of sources of light to be tested, it is desired to move the photometer to and fro over a considerable distance along the photometer-bar. This inconvenience can be effectually reduced by actually attaching the screen to the photometer, so

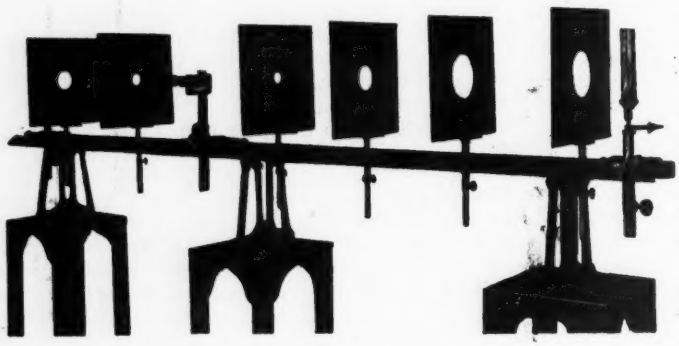


Fig. 1.

that both are moved along the bar together. The author has found the device shown in Figs. 2 and 3 especially handy for this purpose.

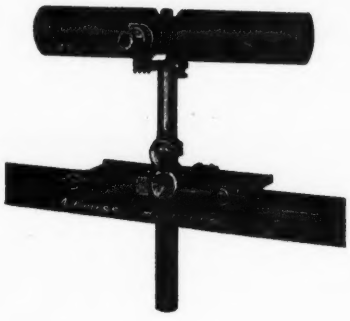


FIG. 2.

The device consists essentially of a hollow tube, the inside of which contains a number of circular blackened screens, pierced with suitable apertures through which the light can pass to the photometric surfaces. The size of these orifices and their distance from the surfaces in the photometer are so chosen as not to interfere with the free passage of the direct rays. On the other hand, all light coming into the tube from the side is reflected to and fro by the blackened surfaces within and effectually absorbed.

This tube cannot be said to render the arrangement of supplementary screens shown in Fig. 1 entirely unnecessary. It may be advisable either

	Without Screens of any kind.	With protecting tube shown in Fig. 2.	With arrangement of screens shown in Fig. 1.
TABLE I.	89·6 H.K. 87·6 ,, 87·4 ,, 89·1 ,, 85·8 ,,	84·0 H.K. 83·4 ,, 81·6 ,, 84·1 ,, 82·8 ,,	84·0 H.K. 82 8 ,, 83·4 ,, 83·4 ,, 81·6 ,,
	Mean 87·9 H.K. Error + 5·9 per cent.	83 2 H.K. + 0·2 per cent.	83·0 H.K. ±0 per cent.
TABLE II.	87·3 H.K. 86·0 ,, 88·0 ,, 87·6 ,, 87·2 ,,	83·0 H.K. 81·6 ,, 82·8 ,, 82·7 ,, 82·2 ,,	80·5 H.K. 82·5 ,, 82·8 ,, 80·7 ,, 81·3 ,,
	Mean 87·2 H.K. Error + 6·9 per cent.	82·5 H.K. + 1·1 per cent.	81·6 H.K. ± 0 per cent.
TABLE III.	145·0 H.K. 148·1 ,, 142·3 ,, 146·7 ,, 140·2 ,,	133·5 H.K. 144·1 ,, 135·0 ,, 136·5 ,, 141·2 ,,	134·1 H.K. 132·6 ,, 135·0 ,, 143·9 ,, 140·2 ,,
	Mean 144·5 H.K. Error + 5·3 per cent.	138·1 H.K. + 0·7 per cent.	137·2 H.K. ± 0 per cent.

to enclose the source of light in some form of light-tight box or to place an additional and relatively large screen in front of it. But there remains the great advantage that practically the entire length of the photometer-bar is free from obstruction, so that the photometer can conveniently be moved to and fro, as desired.

a Lummer-Brodhun photometer, was employed. This bench was supported on three trestles, and was placed at the prescribed distance from the blackened walls of the laboratory. The tests were carried out, firstly, without any screens at all being used; secondly, with the protecting tube device shown in Figs. 2 and 3; and

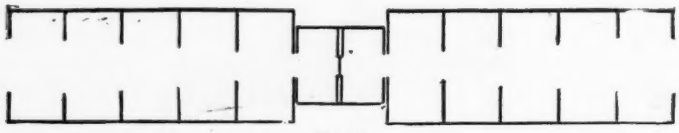


FIG. 3.

Finally, the author gives the results of some experiments which illustrate the practical utility of the methods of protection outlined above. For the purpose of these experiments a standard photometer-bench 2·5 metres long, as utilized in gas-testing, equipped with

thirdly, with the arrangement of screens shown in Fig. 1.

Tables 1 and 2 refer to experiments with an incandescent mantle, and Table 3 to a test on a Lilliput arc lamp taking 1·5 amperes, the intensity being measured in a horizontal direction.

Low Candle-Power Lamps for Sign-Lighting.

UNDER the above title an American contemporary recently referred to the merits of small units for use with illuminated devices. Whatever be the merits of this or that form of lamp for sign illumination, the advocacy of small units of light for this purpose certainly represents a point of view which is well worth consideration.

There are many cases in which a lamp is not, strictly speaking, employed for the purpose of "illuminating"—*i.e.*, of making bright its surroundings. In the case of signs taking the form of patterns composed of glow lamps, all we usually desire is that the individual lamps shall be bright enough to be clearly distinguishable from its surroundings, and if these surroundings are relatively dark a very intense source of light is not necessary. Probably it would often be found that the impression on the eye produced by a cluster of 32 c.-p. lamps instead of 8 c.-p. lamps did not justify the greater expenditure of energy involved. Of course in all such cases there are points of view besides the purely utilitarian to be considered. It is conceivable, for instance, that a shopman might resent the superior brightness of his neighbour's illuminated sign, even though his own achieved its object in being perfectly legible to the passer-by, at a fraction of the running cost.

Many other instances will occur to the reader in which lamps are used, not with a view to illumination, but with the object of indicating the position of something. In all such cases the desirable brilliancy of the source of light is certainly governed by other considerations than those determining the brightness of a source intended to *illuminate*, and therefore merits special consideration.

Gas Testing in London.

By R. Aglio Dibdin.

The Metropolis Gas Act, 1860, provided for the testing of gas by an examiner appointed by the local authority, with apparatus provided by the company. The minimum illuminating power of common gas was fixed at 15 candles when tested in an Argand burner with 15 holes and a 7-inch chimney. The illuminating power of cannel gas was not to be lower than 20 candles when burnt in a batswing burner. The legal candle is defined in this Act as a sperm candle weighing six to the pound, and burning 120 grains each per hour. The tests for purity prescribed in this Act allow 20 grains of sulphur per 100 cubic feet; for ammonia there must be no discoloration of turmeric paper, and for sulphuretted hydrogen no discoloration of lead paper when these papers are exposed to a stream of gas under a pressure of five-tenths of an inch of water for one minute. The local authority and the gas company were, however, at liberty to agree upon other methods of testing for purity. Differences between the authority and the company were to be referred to and determined by arbitration as provided by the Companies' Clauses Consolidation Act of 1845.

The penalty for insufficient illuminating power or purity was not to exceed £50 and £10 in addition for every day the defect continued after notice in writing had been received by the company from the local authority. This penalty was not to be imposed when the company could show unavoidable cause or accident for the defect.

The modern official machinery for testing London gas dates from the City of London Gas Act, 1868, and various Companies' Acts of 1868 and 1869, which embodied more or less completely the provisions in the City of London Gas Act.

These Acts provided for the appointment of a chief gas examiner and three gas referees by the Board of Trade, while the Corporation or Metropolitan Board of Works, as controlling authority, appointed examiners. The chief gas examiner was to hear appeals and to issue a quarterly report on the testings.

The referees were to prescribe the number of times and the mode of testing. The burner for testing the illuminating power of gas was to be the most suitable for obtaining the greatest amount of light and to be practicable for use by the consumer.

The gas was to be wholly free from sulphuretted hydrogen.

The testing places were to be as near to, but not less than 1,000 yards from the gas producing station, and not more than one testing place to any station was to be provided. The companies were to provide the apparatus to be under the control of the authority.

The chief gas examiner's decision in the event of an appeal against a report by a gas examiner was to be final and conclusive. In the event of no appeal being made by the Company the gas examiner's report was to be final and conclusive.

In the City of London Gas Act, 1868, the connexion between quality and price of gas was fixed as follows: The illuminating power after Jan. 1st, 1870, was to be 16 candles, as defined in the Metropolis Act of 1860. The Board of Trade, on the recommendation of the referees, with the consent of the companies and the Corporation, might substitute 14 or 15 candles, accompanied with a reduction in price of 2½*d.* per 1,000 cubic feet per candle.

The price of common gas of 16 candle-power was to be no more than 3*s.* 9*d.* per 1,000 cubic feet. The price of cannel gas was to be proportionate to the illuminating power. In the event of the application by the companies or the Corporation the Board of Trade was to appoint two or three commissioners to revise the scale of illuminating power and price. The forfeitures prescribed were 20*s.* per half candle deficient for every 100,000 cubic feet or fraction thereof made at the station on the day of default; and for purity a forfeiture of £50 per station where the defect occurred per day of default. The forfeitures, of course, were not to be enforced when the company could show unavoidable cause or accident.

In the South Metropolitan Company's Act of 1869 the majority of the above provisions were included, but the candle power was fixed at a minimum of 14 candles, and the price at the maximum of 3*s.* 6*d.* per 1,000 cubic feet.

In the Gas Works Clauses Act (1847) Amendment Act, 1871, it was further provided that five consumers can apply to two justices of the peace, who, by order in writing, may appoint a gas examiner if the local authority is negligent. This applies more particularly to authorities outside London. In country districts one often hears complaints and grumblings about the gas supply. It would be interesting to know how many times the consumers have availed themselves of the power placed in their hands by this Act in order to ensure an adequate supply of gas.

In the Gas Light and Coke Company's and other Gas Companies Act of 1880 an important point is the provision that if on any day there be an excess of impurity, the test for purity on that day shall be taken as the average of the tests on that day and on the day before and on the day following. Another point is that the companies may be represented at the testings on making application in writing in the forenoon of the day previous to that on which they intend their representative to be present.

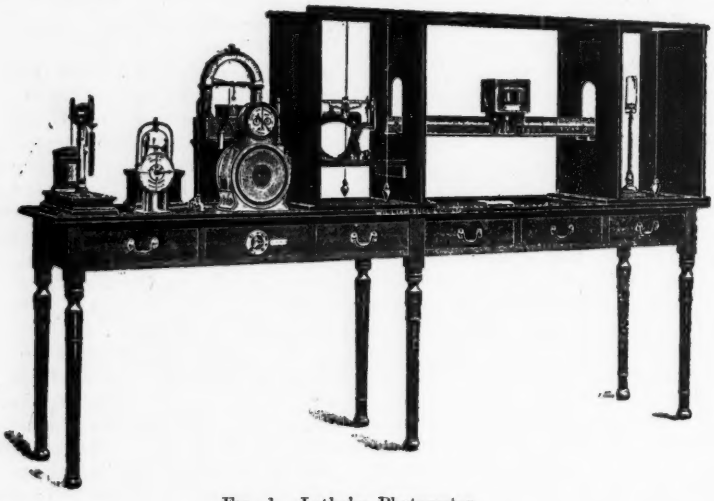


Fig. 1.—Letheby Photometer.

Modifications in the forfeitures and penalties for default were also provided: for example, with regard to illuminating power, the forfeiture for the first half candle of defective power was fixed at 40*s.*, while the forfeiture for the first and every subsequent candle was fixed at not less than £25 nor more than £100. The controlling authority of any testing place having recovered

a forfeiture in respect of any testing place on one day could not recover in respect of any other testing place under their control for default on the same day.

The powers conferred by the above and other Acts allowed considerable changes to be effected in the methods of testing. The Evans and Letheby photometers, both modifications of the Bunsen photometer, were discarded, and the Harcourt table photometer, a modification of the Foucault photometer, was adopted in 1898. The standard candle was a point of contention for a long time. The difficulty of obtaining absolutely reliable candles to conform to the parliamentary standard led to many suggestions. It was also considered desirable to have a standard of comparison which approximated to the intensity of the flame to be tested.

The Board of Trade Committee recommended the adoption of the Dibdin Pentane Argand. The light from this lamp, burning pentane-air, is substantially 10 candles under all conditions of temperature. A change in the height of the flame of 1½ inches makes no appreciable difference in the light emitted from the unscreened portion.

In recommending this lamp as a

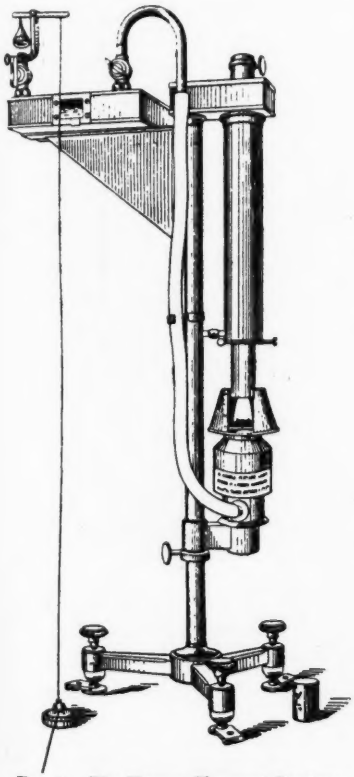


FIG. 2.—The Vernon Harcourt Pentane 10-Candle-Lamp.

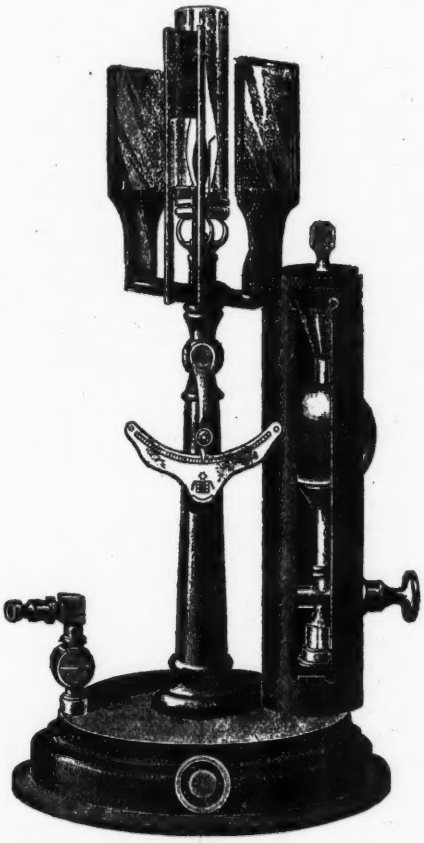


FIG. 3.—W. J. Dibdin's Pentane Argand and Carburetter.

standard the Board of Trade Committee made the proviso that the referees, with the consent of the companies, might adopt any modification or improvement thereof as the standard, provided such modification met with the approval of the Board.

The Harcourt Pentane lamp, which was afterwards adopted, had the working advantage of the absence of a glass chimney, the chimney being metal. The light obtained from the unscreened portion of the flame is accepted as 10 candles when the flame is between certain limits of height. Great care in adjusting the height should be exercised, as the variation with change is much greater with this lamp than with the Dibdin lamp. A further point in favour of the Harcourt lamp is the position of the carburetter. With the Dibdin Argand either a stream of gas from the service or a current of air from a holder is necessary. With the Harcourt lamp the carburetter is above the lamp, and the pentane laden air descends, and the need for a holder is abolished.

The two forms of lamp are illustrated in Figs. 2 and 3.

The Harcourt lamp replaced the candle balance and the use of two candles as the standard in 1898. The method of using the table photometer between that date and 1906 depended on burning the gas in a Sugg's London Argand No. 1 at a fixed distance from the screen, and altering the rate of consumption until the illumination afforded by the gas was equal in intensity to the illumination from the Pentane lamp. The distances of the lamp and the burner from the screen, or photoped, were proportionate by the law of inverse squares to the 10 candles of the lamp, and the 16 or 14 candles afforded by the burner.

The method of burning all gases in a burner with a fixed air supply and a varying rate of consumption was open to objection as a poor gas would be "over-burnt" and a rich one "under-burnt." Although the correct value was assigned to the gas when it was exactly at the standard quality, where there was a variation the readings on the instrument greatly exaggerated the deficit or excess of illuminating power.

The London Gas Act, 1905, extended the "three days' average" to the illuminating power, so that if the average of the testings on one day fell short of the prescribed illuminating power then the illuminating power for the day is taken as the average of the testings on that day, on the preceding day, and on the following day.

The sulphur restriction was removed, and the following clause indicates the

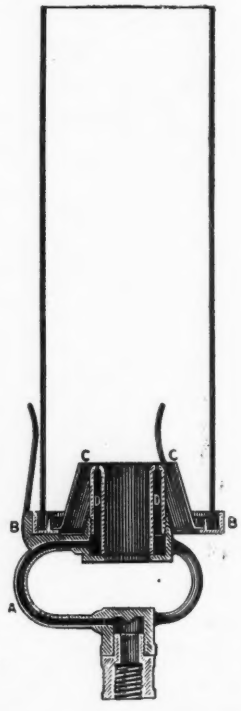


FIG. 4.—Sugg's London Argand No. 1.

introduction of non-obligatory calorific tests and flat flame tests :—

5.—(1) Each gas examiner shall at such places and in such manner as may be from time to time prescribed by the gas referees make testings of the gas supplied by the company for the purpose of ascertaining—

(i) The calorific power ;

(ii) The purity as regards sulphur other than sulphuretted hydrogen ; and

(iii) The illuminating power as ascertained by means of a flat flame burner to be prescribed from time to time by the gas referees, which shall be of the best available pattern.

(2) Each gas examiner shall forthwith deliver to the controlling authority to the gas referees to the chief gas examiner and to the company a report

referees may from time to time prescribe and certify for use for the purposes of this section and shall give to any gas examiner access to any testing place and shall afford to him all facilities for the proper execution of his duty under this section.

(5) A gas examiner shall make in accordance with this section testings at any place prescribed as hereinbefore

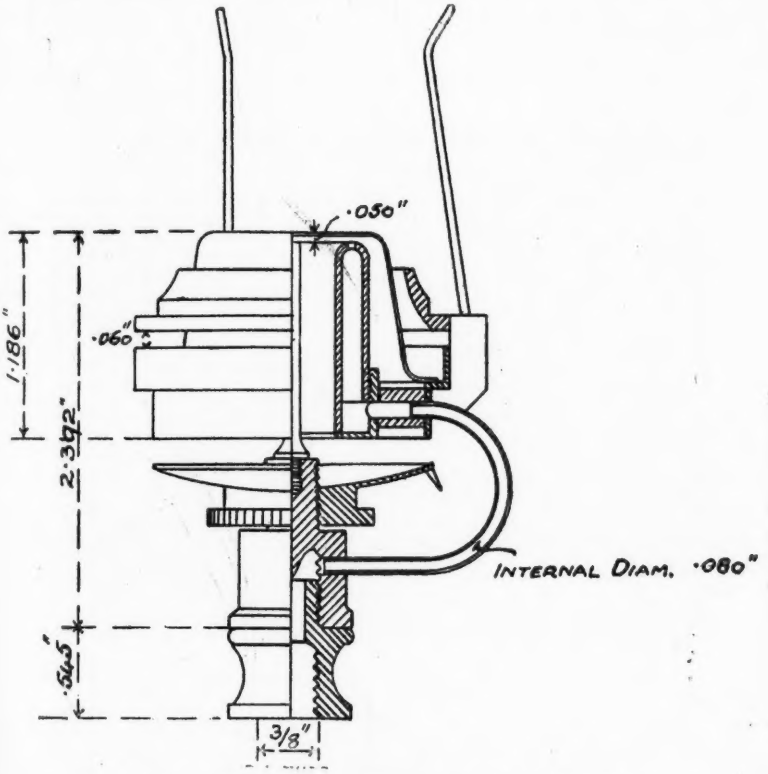


FIG. 5.—Carpenter Metropolitan Argand Burner No. 2.

of the result of each testing conducted by him under the provisions of this section.

(3) The company shall not be liable to forfeitures in respect of any testings made under the provisions of this section.

(4) The company shall provide and maintain at any testing place such apparatus and materials as the gas

provided on such days (exclusive of Sundays) as the controlling authority shall direct.

The Act also makes Sunday testing non-obligatory on the controlling authority.

If the Company neglects or refuses to comply with the prescription of the referees or to maintain any testing place or apparatus, the penalty not

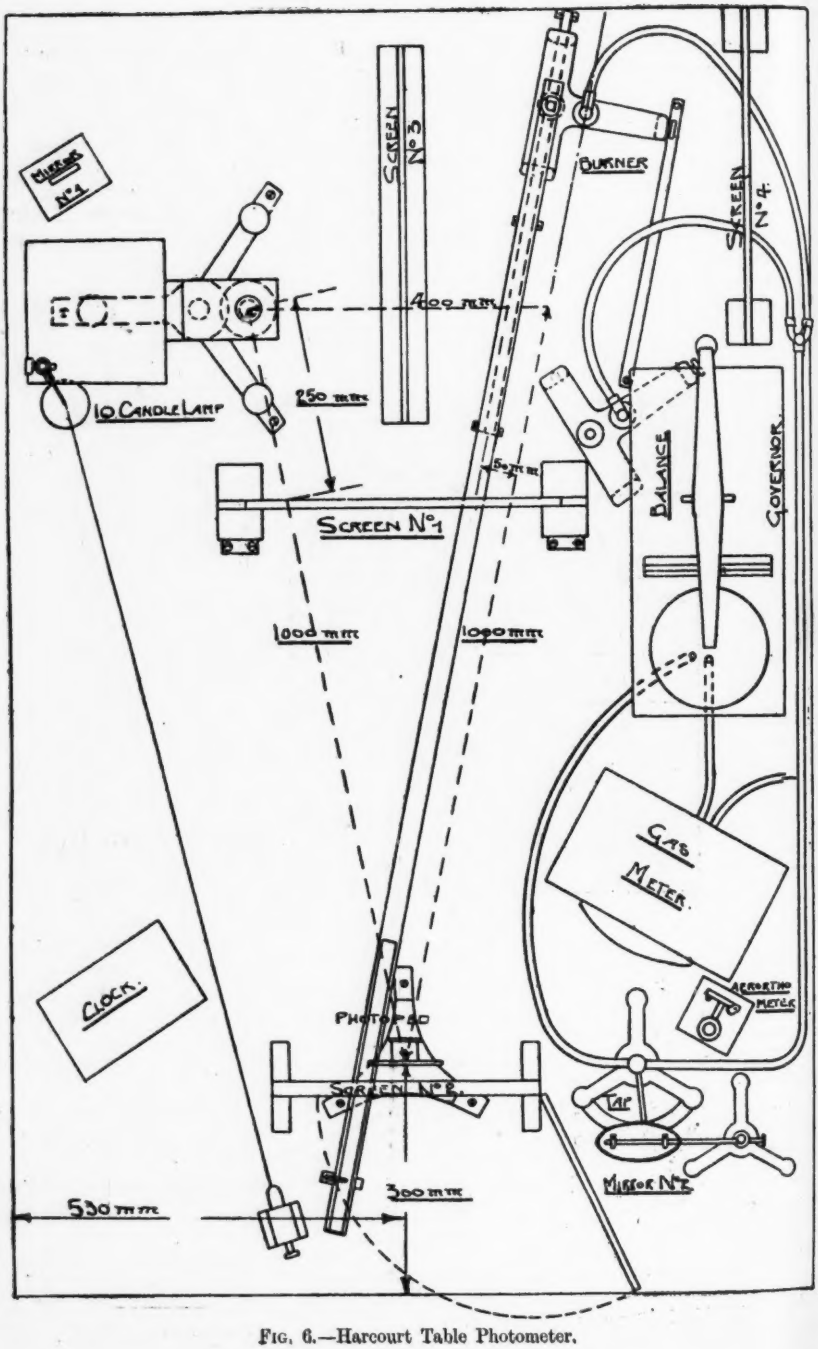


FIG. 6.—Harcourt Table Photometer.

exceeding £50 per day can be imposed on summary conviction.

The foregoing general and rough survey as regards the testing of London gas should give the reader some idea of the importance of the subject. The consumer is guaranteed a supply of gas of a quality corresponding to the maximum price chargeable. The work of the gas examiner, which constitutes, under the Acts, the immediate safeguard of the consumer, is specified in the notification of the gas referees, which is revised from time to time as is provided with a damper, so that the air supply can be adjusted when the rate of burning has been timed to 5 ft. per hour.

Accompanying is a diagram of the photometer table. The operator changes the distance of the burner from the photoped by oscillating the connecting rod until the two lights give equal illuminating effect on the screen of the photoped.

For a test the mean of four readings on the distance scale is taken. This scale on the rod is graduated in candles.

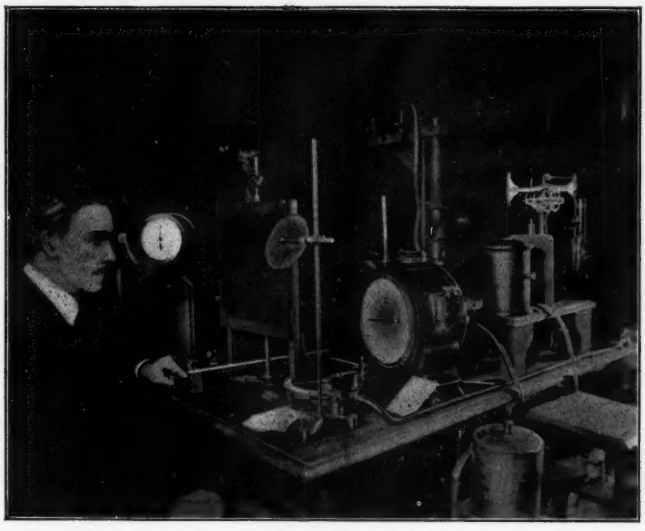


FIG. 7.—Showing photometer-table at testing place. Screens removed to display apparatus.

various modifications or changes seem desirable.

At the present time there are 22 testing places, 2 of which are under the control of the City Corporation, and 20 under the London County Council.

Testings are made daily by a permanent testing staff; and on Sundays, bank holidays, &c., by deputy examiners. Three illuminating power tests are made with the 10 candle pentane lamp, the gas being burnt in Carpenter's "Metropolitan Argand Burner No. 2." (Fig. .) This burner The reading is corrected for temperature of the meter, and the barometric pressure in the room and for the number of seconds taken by the meter hand to revolve twice, indicating the passage of $\frac{1}{2}$ cubic foot of gas. The time must be between 118 and 122 seconds, and the reading of the I.P. is corrected to 120 seconds.

Three tests per day are made with a Bray's burner "marked G/L 5 ft. 15/10, and having a slit 0·028 inch wide."

Before making any illuminating power test gas must be passing through the apparatus for at least 15 minutes.

The examiner must not reject any test "on the ground that the result seems improbable."

The purity tests are for sulphuretted hydrogen and other sulphur compounds. No test is now made for ammonia.

The sulphuretted hydrogen test is made by exposing six strips of absorbent paper, dipped in lead acetate solution, in a glass bell, through which the gas is passing for 3 minutes at about the rate of 5 ft. per hour.

meter is provided with a catch to cut off the gas when 10 ft. have passed.

The condensed liquor containing ammonium sulphate is treated with hydrochloric acid and barium chloride, and the amount of sulphur in 100 cubic feet of gas is calculated from the barium sulphate formed.

The test for calorific power is made on every day except Sundays. This test is for the purpose of collecting information with a view to possible

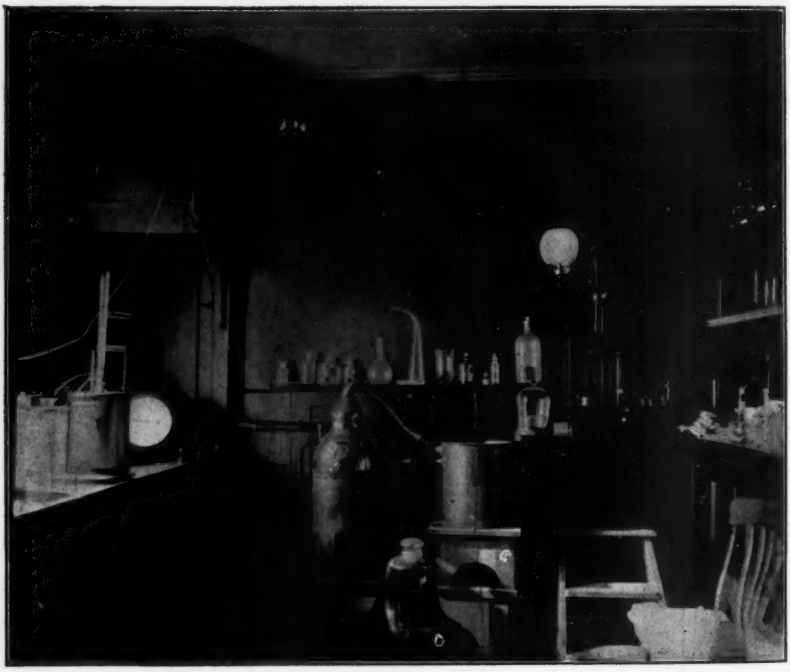


FIG. 8.—Showing Laboratory at a testing place. Calorimeter on the left.

Although the sulphur restriction has been removed, tests are made for other sulphur compounds than sulphuretted hydrogen as a matter of record, and with a view to possible legislation in the future.

Ten feet of gas are burnt at the rate of ½ ft. per hour in a burner round which are arranged pieces of sesquicarbonate of ammonia. The products of combustion are condensed in a tower filled with damp glass balls. The

future legislation. The calorimeter used is one designed by Mr. Boys.

The gas is kept burning and the water running for at least half an hour before any readings are taken. The observations of the temperature of the inflowing and outflowing water extend over 4 to 5 minutes, while ½ cubic foot of gas is burnt. The condensed water is collected for a period of 30 minutes, and, from the amount and the time, the amount of

heat per foot of gas, given to the water passing through the calorimeter, by the condensation of steam in the burnt gas, is calculated and deducted from the gross calorific power.

Occasionally the controlling authority directs testings for pressure to be made at one of the ordinary public lamps. A portable pressure gauge is used. The prescribed pressure must be such as to balance a column of water not less than $\frac{4}{10}$ inch in height between midnight and sunset, and not less than 1 inch between sunset and midnight.

The examiners are specially selected from a large number of candidates. Those selected as most suitable have to pass a severe practical and *viva voce* examination *in the work* of a testing place. Although other qualifications are taken into consideration, the recommendation of gas examiners is a great factor in the selection of candidates for examination. The Act specifies that the examiners shall be impartial men, and the consumers may rest assured that the ordeal through which a candidate, when selected, has to pass before appointment is no light one. The annual cost of testing London gas is somewhere between 6,000*l.* and 7,000*l.* If we assume that a deficit of one candle is a deficit of one-fifteenth of the illuminating power purchased by the consumer, the loss which would be sustained by the consumer for such deficit in 30 million cubic feet of gas would be 6,000*l.* nearly, assuming that the consumer is buying illuminating power, and not merely so many cubic feet of gas.

The total amount of gas sold per annum in London is about thirty to forty thousand million cubic feet, worth some five million pounds, so that the cost of one candle may be put at 300,000*l.* per annum.

The introduction of the incandescent mantle and of the use of gas for cooking makes the calorific value of gas perhaps of greater importance than the illuminating power in many cases. It remains to be proved definitely how far the one value bears a fixed relation to the other. In any future legislation the results compiled by the examiners with the calorimeter as compared with the illuminating values of the gas supplied from day to day, will be of great importance.

Candle-Power Standards for Gas.

In a recent number of the *Electrical Review* of New York, attention was drawn to one seeming anomaly in the methods of testing gas. The writer points out that it is customary to test such lights by means of flame standards, for under these circumstances the influence of alterations in the atmospheric conditions, effect the candle-power of both sources in the same direction.

Yet after all such a method is not strictly logical, because what we are really concerned in is the actual light yielded by the lamp tested, and not the ratio of candle-power, between the standard and this lamp. It is as though we were to measure the efficiency of a heating apparatus by the difference in temperature between the room than of the outside air. As a matter of fact we do not want merely to keep the temperature of our room a certain amount above that of the external atmosphere, but, on the contrary, to maintain the temperature at a certain constant and convenient value, irrespective of the conditions outside.

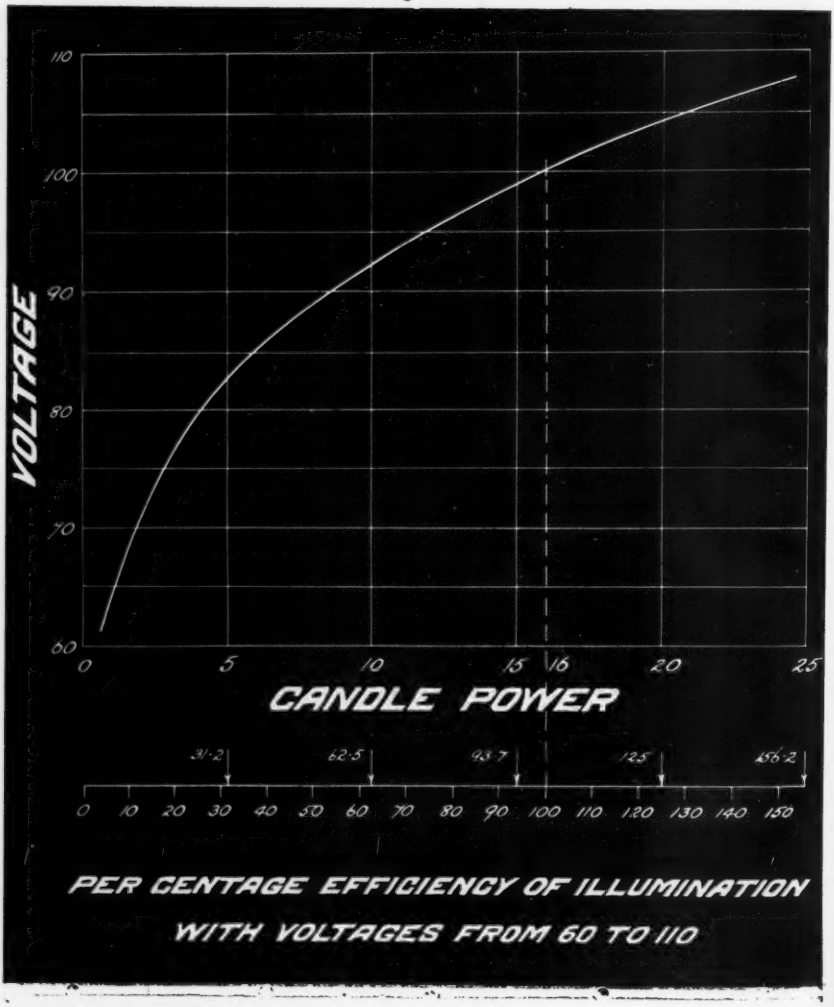
Just in the same way we want our lamp to give a certain amount of light; we are not anxious that it should bear a certain fixed relation to some other lamp when both are varying.

The Effect of Voltage Variation Upon Electric Illumination.

By J. B. Clarke.

From the supply terminals to the lamps of an electric installation there is always a voltage drop or variation due to the resistance of the conducting wires; this has a far-reaching effect upon the illumination, and it is the purpose of this article to show how the size of conductor which will reduce this variation to the lowest degree is arrived at.

The importance of wiring to a specified voltage drop in the conductors of an electric installation becomes apparent when the effect on the illumination emitted by an incandescent electric lamp supplied at varying voltages is considered. The curve which is the result of a test of a nominal 16 candle-power 100 volt



carbon filament lamp, shows this very clearly; the lower line representing the percentage efficiency of illumination at various voltages.

From this it will be observed that a 5 per cent. decrease in the voltage at the lamp terminals gives an efficiency of 74, or a reduction of approximately 26 per cent. in the illuminating power of the lamp; even 2 per cent. decrease of volts produces a considerable reduction in the candle-power, which on an installation of, say, 80–16 c.-p. lamps accounts for a loss of approximately 160 candles.

Since the voltage drop, which so seriously effects the illumination, varies according to the current and the resistance of the conductors, it becomes necessary to carefully consider the means of obtaining the most suitable size of conductor to give a required efficiency.

Taking a case and assuming an installation consisting of 10 electroliers containing 8–16 c.-p. lamps each, radiating from a distributing centre, the length of the circuits being

20	40
30	50
40	60
50	70
60	80
200	300

$$10)500(50$$
$$300$$
$$200$$

or an average of 50 yards each, with the distributing point situated 20 yards from the source of supply, making the total average length of circuit 70 yards, over which a drop in volts of 2 per cent. may be considered permissible.

For a supply pressure of 105 volts this allowance will be 2·1 volts, and it must be apportioned between the main cable and the distributing circuits. The loss in the main being

$$\frac{2{\cdot}1 \times 20}{70} = {\cdot}6 \text{ volt},$$

and in the distributing circuit

$$\frac{2{\cdot}1 \times 50}{70} = 1{\cdot}5 \text{ volts}.$$

In arriving at the current for various circuits it is well to allow for carbon filament lamps 4 watts per candle, or for a 16 c.-p. lamp 64 watts. By dividing the watts by the voltage of supply the current per circuit is obtained.

For 80–16 c.-p. lamps on 105 volt supply the current will be

$$\frac{80 \times 64}{105} = 48{\cdot}76 \text{ amperes},$$

and for 8–16 c.-p. lamps

$$\frac{8 \times 64}{105} = 4{\cdot}87 \text{ amperes}.$$

Calculating the size of the main cable to carry a current of 48·76 amperes with a loss of 0·6 volts, the resistance, by "Ohms" law, $\left(\frac{\text{Volts}}{\text{Amperes}} = \text{Ohms}\right)$ becomes

$$\frac{{\cdot}6}{48{\cdot}76} = {\cdot}0123 \text{ ohms},$$

the circuit being 20 yards, or a total of 40 yards of conductor which is required to have this resistance.

Most tables of conductors give the resistance of all sizes of conductor per 1,000 yards. For direct comparison it is therefore necessary to find the resistance the conductor will have per 1,000 yards, *i.e.*,

$$\frac{{\cdot}0123 \times 1000}{40} = {\cdot}3075 \text{ ohms}$$

per 1,000 yards; for this 19/15 S.W.G. having a nominal sectional area of ·075 square inches and a resistance of ·3167 ohms per 1,000 yards would be selected.

In the absence of a table the area of the cable may be found by dividing ·0241 by the resistance per 1,000 yards of the conductor.

In this case:

$$\frac{{\cdot}0241}{{\cdot}3075} = {\cdot}0783 \text{ sq. inch}.$$

This method gives the correct area, but the nearest manufactured size is ·075 sq. inch or 19/15 S.W.G. as before.

For the distributing circuits, selecting the one of longest run, viz., 80 yards, in which 1·5 volts drop is allowed, and a current of 4·87 amperes, the resistance is $\frac{1{\cdot}5}{4{\cdot}87} = {\cdot}308$ ohms, the length of conductor being 160 yards, which must

have this resistance, and is therefore equivalent to a conductor of

$$\frac{\cdot 308 \times 1000}{160} = 1 \cdot 92 \text{ ohms per 1,000 yards.}$$

For this 7/18 S.W.G. having a resistance of 1·93 ohms per 1,000 yards would be selected.

For the other circuits the sizes would be proportioned accordingly, depending upon their length, except in the case of short runs, when the size of conductor may be based upon the carrying capacity, allowing 1,000 amperes per square inch of sectional area. Generally speaking, if the run of the circuit is less than 40 yards, and the current density 1,000 amps. per square inch, the voltage drop for any given number of watts transmitted along the cable will be within 2 per cent. of the pressure of supply.

From the foregoing it will be seen that to base the size of the wires throughout on the carrying capacity of 1,000 amps. per square inch would seriously intensify the difficulties of efficiently illuminating large halls and churches, where the length of circuit is considerable.

In the example a 7/18 S.W.G. conductor is required for a current of 4·87 amperes, but in customary practice for short runs this wire would carry treble the current, for at 1,000 amps. per square inch the capacity is 12·5 amps., and by the I.E.E. rules 21 amperes may safely be carried before the temperature effect is sufficient to be taken into consideration. This latter value is a fallacy which often leads contractors to under-estimate the size of wires and produces tenders of disproportionate amounts.

Dust and Illuminating Engineering.

THERE are probably many cases in which the importance of keeping the bulbs of glow-lamps or the chimneys and shades of incandescent mantles as clean as possible is not sufficiently realized. The introduction of a glow-lamp which was 25 per cent. more efficient than any of its predecessors, or of a form of reflector or globe the coefficient of reflection of which was say, only 10 per cent. higher than that of others, would arouse very great interest.

Yet it is safe to say that these figures are comparable with or in many cases far smaller than the loss of light very frequently occasioned by want of cleanliness. Thus Messrs. Legg and Townsend recently found that the effect of dusting the lamps in a reading-room in Chicago was to increase the illumination, on the average, by 25 per cent., and in one case by as much as 75 per cent. It may confidently be asserted that in many factories, where the conditions as regards cleanliness are so much less favourable, these figures would be exceeded.

Judging by results, therefore, it may be said that the man who introduces a system of supervision by means of which all globes and reflectors, &c., are kept clean, and saves a considerable amount of light thereby, deserves, at least, a share of the credit which is given to the engineer who accomplishes the same result by the design of entirely new apparatus.

The Development and Prospects of the Metallic Filament Glow Lamps.

By Dr. Felix Jacobsohn.

There is scarcely any branch of industry in which such strenuous efforts towards progress have been made during the last century as in the production of illumination. Each of the two great rival methods of producing light, gas and electricity, has done its utmost to imitate and excel the progress of the other. When, thirty years ago, the first electrical glow-lamp came upon the market, the new invention was hailed with acclamation; nevertheless these lamps consumed the relatively high amount of power of 4·5 to 5 watts per c.-p., and attention was at once bestowed on the possibility of improving these results. But it was the discovery of the incandescent mantle by Auer v. Welsbach and the realization that the hitherto decried illumination by gas had now become a formidable competitor, that stimulated those connected with electric lighting to set to work in earnest. Even when it became possible to produce lamps which could burn with a consumption of 3·5. watt, or—in the case of higher pressures—2·5 to 3 watt per c.-p., there was still every reason to fear that electricity could not compete with the incandescent mantle as regards cheapness. Among the marvellous results achieved indirectly by Welsbach's invention, we may point to the stimulus that was given to the progress of scientific investigation in fields of knowledge which had hitherto only been superficially covered. As a result immense progress in certain directions has been made, and the incandescent lamp industry has been stimulated to seek for other materials in the place of carbon for glow-lamp manufacture; hence the arrival of the metal filament lamp.

The chief weaknesses of the carbon filament lamp are already recognized; what then are the qualities which the desired material must possess? Briefly these may be described as follows: high electrical specific resistance, high melting point, durability, disinclination to volatilize, and lastly ease of manufacture. It was of course soon realized that the material with these ideal qualities did not exist. The already well-known platinum had too low a resistance, and its fellow metal in the same group, Osmium, could only be worked with difficulty. Eventually almost all the elements having relatively high melting point and low conductivity were subjected to investigation, there being always a prospect of somehow finding means to overcome the difficulties militating against their practical utilization. While we must, of course, realize that the application of these materials to the glow-lamp industry is still far from complete, one cannot but be amazed at the scientific progress which has accompanied the development of this branch of industry. Only ten years ago even the most important compounds of the rare elements were barely known. Who, therefore, would have predicted that by to-day we should have learnt how to obtain the pure metal and even to draw this metal into the very finest threads in order to utilize them as filaments?

The results of almost every investigation of this nature were protected, so that there exists to-day an almost innumerable number of patents bearing on this special subject alone. In this connexion one cannot help drawing attention to the misuse of the process of patenting which takes place in connexion with any novelty. In the metallic filament industry, for instance, patent rights have been secured for many unworkable and, from the chemical standpoint, positively ridiculous processes, which it is safe to say will

never be worked and still less find their way to practical utility. In such cases the firms in question simply take out a patent, which is soon allowed to lapse, with the object of securing the whole field for themselves and preventing any possible competition.

In what follows we shall only deal with the German patents bearing on the subject, but these naturally afford a very complete review of the most important recent developments. In this connexion the elements occurring in the following groups call for consideration :—

In the Platinum Group, Osmium, Iridium, Ruthenium, Rhodium.

In the Oxygen Group, Chromium, Molybdenum, Wolfram, Uranium.

In the Fifth Group of the Periodic System, Vanadium, Niobium, Tantalum.

Among the Tetravalent elements, Titanium, Zirconium, Thorium.

Finally there remain *the Septavalant Element*, Manganese, several rare earth-metals, and also Boron and Silicon.

Among the various methods of producing metal filaments we may mention four chief processes ; there are, *firstly*, the pressing and drawing methods, by means of which the filament is actually pressed or drawn out into thin wire; *secondly*, substitution methods, according to which the carbon filament is brought to incandescence in an atmosphere of volatile metallic compounds, so that the carbon is eventually replaced by the desired metal ; *thirdly*, paste-methods, in which the metal or an easily reduced metallic compound is prepared in a finely divided state, mixed with some organic binding material into a paste, and then pressed through fine dies into wires ; *fourthly*, there is a special modification of the paste process due to Dr. Kuzel, which we will mention later on in this article. Yet one remark may be added concerning the difficulty of drawing rigid distinctions as regards the variety of processes to be dealt with. While in the main only filaments which are of a truly metallic nature will be mentioned, it may also be inevitable for metallic carbides and oxides to be also touched upon. On the other hand, incandescent bodies which conduct as conductors of the second class, in a purely electrolytic manner, will be excluded.

The utilization of Iridium for filaments of glow-lamps forms the subject of several German patents (class 21 F., Nos. 145456 and 145457) of R. J. Gülcher of Charlottenburg. In accordance with these patents finely divided Iridium is mixed with an organic binding material, pressed out into fine filaments, and heated in the air by means of a Oxy-Hydrogen blow-pipe flame. The subsequent patent mentioned refers to the reduction of the Iridium from the Oxide by incandescence in a stream of hydrogen. Iridium cannot be said to be well adapted to glow-lamp manufacture, for its hardness and brittleness do not admit of its being drawn out finer than about 0·8 mm. Lamps so constructed are, however, only intended for low voltages, such as are supplied by small batteries or accumulators. As usually manufactured they consume from 1 to 1·5 watt per H.K., and are not intended for pressures higher than about 24 volts.

The patents dealing with the application of Osmium to glow-lamp filaments are very much more numerous. The inventor of the Osmium lamp is Dr. Carl Auer v. Welsbach, who was also responsible for the discovery of the incandescent mantle, which has opened a new era in the gas-lighting industry. In the first of these patents (German patent 138135) he describes two processes for the manufacture of filaments of Osmium according to the so-called deposition method. A platinum core is brought to incandescence in an atmosphere of the vapour of Osmium-tetroxide together with water-vapour and reducing Hydrocarbons. As a result the majority of the platinum present disappears in the form of vapour and there remains a tube of Osmium, still, however, containing traces of the platinum ingredient. The second so-called Osmium and Carbon process is essentially the same as the paste processes so largely used at the present time. There is also a method of impregnating natural or artificial threads with salts of Osmium and with the addition of other possible ingredients

such as Ruthenium, Rhodium, Iridium, and Thorium and Zirconium Oxides.

According to the German patent 132428 Dr. Fritz Blau and the "Watt" Elektrische Glühlampenfabrik of Vienna utilize the substitution process for the manufacture of filaments of Osmium and Ruthenium. According to this process carbon filaments are burned in an atmosphere of the vapour of Osmium and Ruthenium tetroxide, when the change expressed by the following equations takes place :—

I. $OsO_4 + 2C = 2CO_2 + Os$

II. $OsO_4 + 4C = 4CO + Os$

In the neighbouring patents (138315 and 140468) the Austrian Incandescent Gaslight and Electrical Company advocates the addition of oxides which are volatilised at a white heat, such as those of Titanium and Magnesium clay (not sand), to the Osmium paste, with the result that a more homogeneous Osmium filament can be obtained; also by the further addition of Thorium or Zirconium Oxides the Osmium is coated with a thin layer of the Oxide referred to. According to another patent (German patent 143352) the life and durability of Osmium filaments are improved by a special process involving heating in a vacuum, and consequent expulsion of water vapour and carbonic acid or Hydrogen occluded in the filament. Subsequently (German patent 143454) small quantities of air or Oxygen were admitted to the glowing Osmium filament with the object of accomplishing complete oxidization of the carbonaceous constituents and preventing the possibility of subsequent black deposits on the globe of the lamp.

The German Gasglühlicht-Actien-Gesellschaft of Berlin have also taken out a succession of supplementary patents in continuation of the original master patent of Auer v. Welsbach. For instance, patent No. 162705 of 1899 refers to the use with Osmium or other metals in the platinum group, of small quantities of carbon, thorium, niobium, tantulum, titanium, silicon, and other metals, which are more easily oxidizable than Osmium, so that the Oxide is reduced by the occluded gases or carbonaceous material present in the filament. With this object the porous Osmium filaments are coated with a thin paste of some material containing Oxygen and carbonaceous constituents, and the resulting alloy is said to result in greater elasticity than occurs in the case of filaments made of pure Osmium. In the German patent 174221 of 1905 this company turns its attention to alloying Osmium filaments with Chromium, Molydenum, and Wolfram. The manufacture of these filaments is carried out by the paste process, according to which metallic Osmium, together with the other metals present as Oxides, is formed into a paste with the necessary carbonaceous binding material. According to patent 185545 of 1905 the Auer-Gesellschaft overcome the natural brittleness of Osmium and Iridium by alloying with tin. The relatively easily pulverized material is then converted into light-giving filaments by the paste process in the usual way.

According to patent 154412 Albrecht Heil of Frankfurt obtains extremely fine Osmium filaments by electrolytically dissolving off the surface of an ordinary Osmium wire which serves as an Anode.

After reviewing the patents bearing on utilization of Osmium and its homologues to glow-lamp manufacture, we are driven to the conclusion that pure Osmium is but ill-adapted for this purpose. Apart from the difficulties in manufacture of such filaments and their comparative fragility, the exceedingly high price of the metal is a drawback to its extensive use in this connexion. Lamps containing Osmium pure and simple are not now found on the market in any great quantity. Such lamps could only be manufactured for pressures up to 47 volts, so that it was necessary to run several lamps in series on the customary pressure of 100 volts and over. The consumption of power is in the neighbourhood of 1·5 watts per H.K. The weakness of the filament only enabled these lamps to be used in a hanging vertical position.

It may be stated that the other lamps now in use provided with names closely resembling "Osmium" have

really little but the name in common. For instance, the filament and the Osram lamp of the Deutsche-Gasglühlicht-Gesellschaft most probably consists mainly of Wolfram. With careful use these lamps give excellent results, in many cases burning for as long as 1,000 hours. In the case of 25–32 c.-p. lamps the consumption of power is 1·12 and 1·08 watts per H.K. respectively. Lamps of lower intensity than 40 to 50 candle-power cannot be produced for 200 volts, the consumption in this case being 1·2 watts per H.K.; in the case of 50–200 c.-p. lamps this is reduced to 1 watt per H.K.

The so-called "Osmin" lamp of the Osmium-Licht-Unternehmung of Vienna yields about 60 candle-power at a consumption of 1·05 watts per H.K. Lamps intended for 200 volts yield 80 c.-p. In order to accomplish these results, filaments as thin as 0·03 mm. in diameter—that is about half the thickness of fine ladies' hair—are essential, so that it hardly seems possible to produce these metallic filament lamps for voltages in the neighbourhood of 100 with an intensity of less than 30 to 40 candle-power.

We now come to the metals in the sixth carbon in the periodic system, one of which—Wolfram—has already been mentioned. The most important patent bearing on the use of Molybdenum and Wolfram is that of Alex. Just and Franz Hanamann of Vienna (German patent 154262, 1904); it refers to the substitution of the material of carbon filament by some other substance, this being accomplished by bringing the filament to a high temperature in an atmosphere of the vapour of the Oxichloride of Molybdenum or Wolfram, a small quantity of Hydrogen also being present. The process takes place according to the equations :—

$$WO_2Cl_2 + C_2 + H_2 = 2HCl + 2CO + W$$

$$WOCl_4 + C + 2H_2 = 4HCl + CO + W$$

The presence of this Hydrogen is absolutely essential to the success of the process, for otherwise not only no reduction of the metal, but no oxidization of the carbonaceous material could take place. By means of further reduction of the Oxichloride in a stream of Hydrogen, the Wolfram filament can be materially strengthened. The Vereinigte-Elektricitäts-Actien-Gesellschaft of Ujpest, who hold the license to manufacture in Austro-Hungary, Russia, Belgium, Italy, Spain, and Portugal, state that finer filaments can be produced in this way than by the paste process. The holder of the German patent is the Wolfram-Actien-Gesellschaft of Augsburg, who have taken over the rights of manufacture of the firm of Geo. Ludicke & Co., Lechausen.

In a more recent patent (February, 1905) Dr. Just has returned to the paste process; he brings finely divided metals into intimate contact with some liquid which is, however, free from carbonaceous materials, the paste so obtained being pressed into filaments and reduction being completed in a stream of Hydrogen. By this process lamps for 110 volts burning at 1 watt per H.K. giving 30–40 candle-power can be produced.

Although other metals of this group possess similar qualities to Wolfram as regards high melting point, only this particular metal appears to have been actually utilized. Chromium, produced by Moissan's process in the electrical furnace, melts at a much higher temperature than platinum, and appears to be easily workable when sufficiently pure; its degree of hardness is less than that of glass. Metallic Molybdenum can be easily obtained by reduction of the Oxide with carbon, water vapour, and aluminium (Goldschmidt's process). In this case one employs by preference the known volatile brown Molybdenum dioxide (see the method of Biltz of Kiel), in order to avoid the generation of heat and great loss of material through evaporation which occurs in the case of the yellow-green trioxide.

By means of this process Molybdenum is obtained as a workable metallic regulus, which is subsequently mixed with 1 to 2 per cent. of clay. Molybdenum may be easily obtained by reduction of the easily volatile chloride in a stream of Hydrogen, as a very fine and pure powder. By

Moissan's process* it is only fusible at the higher temperatures of the electrical furnace, and under these conditions becomes malleable. Wolfram is obtained in a metallic state by a very similar process to this employed in the case of Molybdenum.† Hallopeau,‡ however, describes a method by means of which Wolfram separates out in the metallic state when the Lithium Parawolframate is melted and subjected to Electrolysis. It is conceivable that this might open out a way of preparing Wolfram filaments in which the electrodes consisted of the supports to which the filaments are attached. Emphasis, however, must be laid upon the fact that the Electrolysis of molten material is much more complicated than that of aqueous solutions on account of the numberless inconvenient phenomena accompanying the production of the misty metallic vapour.

The metal Wolfram is even more fusible than Chromium and Molybdenum, its density being about eighteen. Uranium, which can be obtained in the metallic state by similar processes to those used in the case of its homologues‖ is, in spite of its metallic resemblance to the metals referred to, but little adapted to the manufacture of metallic glow-lamp filaments, for it melts at a lower temperature than iron; for this reason all the patents which have been taken out with the object of utilizing Uranium for this purpose are illusory.

(To be continued.)

* *Compt. rend.*, **116,** 1225, 1893; **120,** 1320, 1895.

† Moissan, *Compt. rend.*, **116,** *l.c.*; **123,** 13, 1896. *An. Chim. Phys.*, **8,** 570, 1896.

‡ *Compt. rend.*, **127,** 755, 1898.

‖ Moissan, *Compt. rend.*, **116,** 349, 1893. 'Ueber die Schmelzflüssige Elektrolyse von $UCl_4.2ClN_a$ bei 50 Amp. und 8-10 Volt' see *Compt. rend.*, **122,** 1088, 1896.

Efficiency of Various Electric Lamps.

An American correspondent sends us the following interesting set of figures relating to the actual efficiency of various electrical illuminants:—

COMPARATIVE VALUES OF VARIOUS FORMS OF ELECTRIC LAMPS,
As given by Mr. Arthur Sweet, Westinghouse Co., Newark, N. J.,
Before the Pittsburg Section of the Illuminating Engineering Society, June 8th, 1907.

KIND OF LAMP.	Mean Spherical Candle Power.	Watts per candle.	Candles per Kw.
Common 56 watt carbon filament incandescent lamp, rated at 3·5 w.p.c. 16 horizontal candle power	13·2	4·24	236
Common 50 watt Carbon filament incandescent lamp, rated at 3·1 w.p.c. 16 horizontal candle power	13·2	3·78	264
Three-glower, 264 watt Nernst lamp	81·0	3·26	307
GEM 125 watt, graphitized carbon filament lamp of 50 horizontal candle power	40·7	3·07	326
44 watt Tantalum lamp, rated at 22 horizontal candle power	16·0	2·75	364
Direct current 5·1 ampere enclosed arc on 110 volt circuit, 1·5 in. carbons	213·0	2·63	380
Alternating current enclosed 5·7 ampere arc, taking 388n watts on 110 volt circuit, 5 in. carbons	152·0	2·55	392
60 watt 110 volt Tungsten filament lamp, burning at 1·25 watts per horizontal candle	37·0	1·62	617
Luminous 8 ampere arc 440 watt, two in series on 110 volt circuit	1080·0	·431	2,320

SPECIAL SECTION.

The Relation of Architectural Principles to Illuminating Engineering Practice.

By Bassett Jones.

(A Paper read before the Illuminating Engineering Society, Dec. 12, 1907. Conditions of space do not enable us to reproduce Mr. Bassett Jones's valuable paper and the instructive discussion following it *in extenso*, and we content ourselves with bringing before our readers some of the most interesting features in full, and referring to the remainder in abstract.)

In sections (1) to (22) Mr. Bassett Jones explains some of the complex principles upon which our own impressions of beauty depend. Successful illumination of structures, making an appeal to this sense of beauty, demands sympathy with the æsthetic qualities of the design, and the engineer who, unfortunately, has not always the opportunity of learning to appreciate beautiful things, is apt to lay undue stress on "practical considerations." The author considers that the engineer who fails to appreciate the æsthetic side of lighting will not receive the recognition that the importance of his work demands. Let us in the first place consider what is involved in the term "æsthetic." What, therefore, are the sensations which an artistic creation calls into play?

In the first place such a creation must arouse the curiosity and challenge the attention of the observer, and this it does mainly by producing a delicate mental poise between recognition and novelty. But the attention so aroused is maintained primarily by the sympathy of the onlooker—a feeling that the design expresses his own ideas, and strikes him as appropriate. When an object strikes us as being beautiful we experience actual physically pleasurable sensations. Thus the sense of ease and abandon with which our eye travels over a beautiful curve is gratifying to the senses. There is no abrupt alteration in the orderly sequence of muscular efforts required.

Yet apart from such actual physical pleasure, we derive intellectual enjoyment from the play of imagination—the train of associations and ideas which an artistic object calls forth.

Here, of course, previous artistic training comes in. Readiness in appreciating the harmonious or incongruous qualities of a scheme of decoration demands artistic knowledge. In many cases the artistically ignorant man would not notice any incongruities, nor would he notice the congruity.

The feeling of peace and restfulness, called forth by much of the best architecture is chiefly dependent upon harmonious proportions. Continual experience of the contrast between safe and unsafe construction is the basis upon which the imagination builds the æsthetic qualities of proportion; but this feeling is complicated by the sense of *familiarity*, and other overlapping impressions.

Beauty, therefore, may be of different kinds, and may call forth a very complex series of emotions. Let us now consider its application to the principles of architecture.

The Principles of Architecture.

(23) The impulse to avoid injurious or painful stimuli and prolong pleasurable stimuli, is the foundation of all organic activities. With the rise of consciousness and the development of volition this impulse becomes, we may almost say, the fundamental purpose in life. In the higher reaches of mental development this purpose makes itself evident in an almost infinite variety of attempts so to modify the environment that its pleasure-giving stimuli will be greatly in preponderance over its pain-giving stimuli. Any object that furthers this end is termed "useful," whether that object be a lead pencil or the canvas of a master. This, the utilitarian purpose, is the basic actuating principle of all our beneficial activities. Distorted and misdirected, it also becomes the fundamental source of evil.

(24) Architecture, then, primarily has for its purpose the provision of structures designed to furnish protection from the vicissitudes of climate, and the fulfilment of this purpose alone is sufficient to give pleasure of a very elementary sort. The requirement of familiarity then demands of the architect that his structures shall so appeal to memory as to make evident its secondary purpose. The pleasure is not in the puzzle, but in its solution. The mind instinctively asks, "What is the thing for?" and unless the answer is forthcoming, no amount of grace or ornament can overcome the ensuing feeling of repulsion. We find ourselves in a strange place, and the ruling impulse is to escape.

(25) The tendency to make every useful object more pleasing is, as we have noted, fundamental in the imagining activities of the mind, and there naturally results an effort so to fashion the object that while it still serves its primary utilitarian purpose, it will stimulate the senses in a manner conducive to the greatest amount of pleasure possible. We have seen that this effort finds its highest expression in the form known as æsthetic, and that the perception of the beautiful makes three demands upon the object:—

(*a*) The sensations aroused by the object shall be of such a form that they may be readily responded to by the organism in its habitual manner, and,



FIG. 1.—Old English Wall Bracket.

therefore, there must be no discontinuity or sudden alteration in their flow. If discontinuity occurs, the reason for it must be evident and natural. Some attractive provision must be made, often by means of appropriate ornament, so that the mind can readily bridge the gap. Take, as an example, the old English

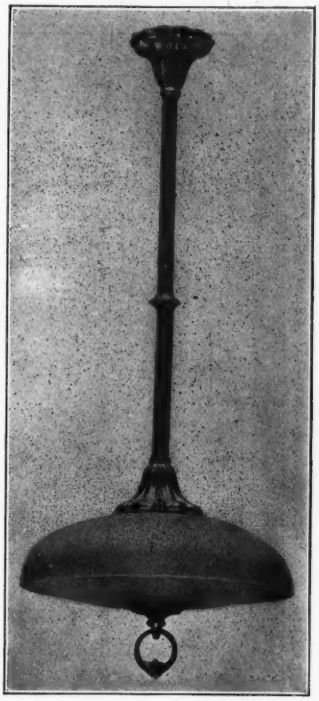


FIG. 2.—Showing Clever Use of Ornaments.

wall bracket shown in Fig. 1. Its great charm lies in an exquisite harmony of curves. The lines generating each part sweep into one another without break or raggedness. The eye follows its contours with pleasurable ease. Beauty has been added to usefulness by conceding to the simple demands of the visual sense. On the other hand, we have in Fig. 2 a discontinuity in lines cleverly bridged by decorative ornament. So the architect, in designing a building, must contrive its featural lines so that the eye can follow them and the mind perceive them in a natural and unconstrained manner.

(*b*) The object must be sufficiently suggestive in its aspect to demand some effort of the imagination in discovering its full meaning and relations to its environment. The interior shown in Fig. 3 finds, perhaps, its greatest æsthetic effect in its religious symbolism. To those to whom the appeal can be

made it suggests the strength and mysticism of the early Christianity. Its feeling is tense with the exalted religious spirit of its builders. It has a story to tell, and is successful because it is full of imaginative suggestion. It carries us beyond its bare objective presence to a realm of ideal and contemplative construction that transcends the limits of actual experience.

(c) The several parts of the object must be in harmony. This requires that the parts be different, while at the same time the perception of each part must lead naturally (with smooth organic flexes) to the perception of the next. The relations between the parts, and the relation of each part to the whole, must be reasonably evident....

(26) The requirement, that the several parts of the object or building shall arouse concordant sensations, demands



FIG. 3.—Lighting of Westminster Abbey Choir.

that the relations between the several parts of the object shall be apparent. The technical name of this character is "proportion." Its importance cannot be over-estimated. And we find throughout ancient classical architecture an evident attempt to carry it to its logical extreme....

(27) We have earlier (§§ 15, 16) touched upon the sense of structural proportion aroused by experience with safe and unsafe construction, and it only remains for us to draw conclusions in the light of our study of the memory coefficient. We must remember that the use of steel, and similar materials requiring slender proportions, is of very recent occurrence So far is this true that any degree of study of the æsthetic features of buildings will produce a great superabundance of feeling for the heavier construction of wood and stone. And the memory coefficient will naturally produce a sentiment in favour of heavy proportions, even where steel is used. The time is by no means ripe for a deliberate use of steel as steel, unless some means is adopted to increase its apparent weight. This requirement, of course, does not occur in subsidiary construction, where there is historic precedent, although this must not be taken as a reason for ignoring the structural proportions of the environment. To take an example, a lighting fixture must be proportionately heavy, if it is to be employed in a room of massive construction. Otherwise the feeling of balance will be disturbed. This, I may remark in passing, is a rule that has not been duly considered in some recent discussions of fixture design.

(28) A simple example serving to illustrate the basic organic principle of proportion is given in Fig. 4. The square there shown has a certain proportion between its sides due to the fact that their relation is of the order of unity. There is, however, no appeal to the attention because the case is one of mere repetition, and possesses no novelty. A single glance of the eye is sufficient to determine all its possibilities. The imagination remains dormant. But let us lengthen two of the sides so that their relation to the remaining sides is of the order two to one. At once we perceive the difference. There is an alteration in the form of the visual sensation as the eye passes from one side to the next. The attention is at once challenged, and curiosity is aroused. But there is no confusion between the perceptions of any two adjacent sides, and the mind readily adapts itself to the order of change.

Now turn to Fig. 5. This interior at once appeals to the attention, and for the reason noted above. The featural lines form a definite proportion, the one with the next following. A scaled section of the building would make this evident at once. The enclosed spaces are also in proportion to each other, and in proportion to the lines bounding them. Where the eye is likely to find any abruptness, ornament has been well used to detain the attention and make the transition more gradual. And this brings us to the last point we have time to discuss—the use of ornament.

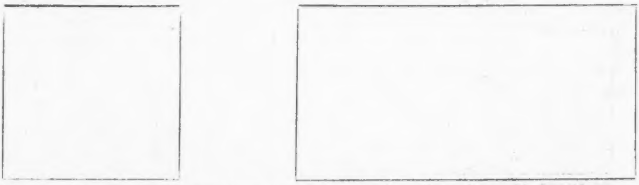


FIG. 4.—Example Illustrating the Basic Organic Principle of Proportion.

(29) The genesis of ornament has its root in the very human characters of conceit and pride. It appears first in the rings and feathers of the savage and in the war paint of the Indian, expressing the desire to improve and accent the object of beauty, or ferociousness, that appeals to the elemental mind. But we, whose trained intellects can grasp the true worth of proportion, require no bangles or paint to attract our attention to the naked beauty of the human form.

(30) As Ruskin has expressed it, "The works of God are perfect." They are so admirably fitted and proportioned to the fulfilment of their purpose that ornament could only serve to mar their beauty. But human effort and skill are so far limited that the deed is never the perfection of the thought. The meaning is always clouded by the ineffectiveness of its presentation.

(31) This lack of unambiguous expression of the function of each part of our

utilitarian construction compels the use of ornament as a means of emphasis and as a sign of the use to which each part is put; for parts differing in function must differ in appearance. Is it not evident, then, that in the proper or improper use of ornament is the success or failure of the whole design? And it is also evident that the slavish use of decoration is but a concession to bad proportion and lack of expressive ideas. Ornament, not to be vulgar, must be handled with most exquisite taste and sense of propriety, for in ornament more than in anything else we may read the mental standards of the period. An intimate knowledge of its history and use is essential for its proper treatment. Fig. 6 is inserted as an example of the perverted use of ornament to hide the lack of constructive lines.

The Architect and the Illuminating Engineer.

(32) The principles of architecture are, we now see, no mere whim on the part of the designer. They are as deeply rooted in a basis of fact as are the principles of natural philosophy. The conceptions of good architecture are subject to the same order of constraint that limits the postulates of science.



FIG. 5.—St. Sulpice Nave, showing Lighting Fixtures Suspended from Roof.

(33) I have considered it necessary to devote so much of our time to this inadequate and sketchy outline, because I have noted, on the part of many contributors to the literature of illumination, a disposition to decry and criticize the limitations which architects place upon their work. They do not seem to realize that the beauty and effectiveness of good architectural construction, both from æsthetic and utilitarian standpoints, de-

pend upon a strict adherence to the principles outlined above, and that the feeling of the design, dependent, as it must be, upon historical precedent, is bound by centuries of usage to certain effects of colour and light which have become established because of their appeal to the sentiments aroused by pleasurable visual perception. The business of the illuminating engineer is to modernize old methods of illumination without destroying them. If we are to discard tradition altogether, then we may as well abandon the architecture of the past, and ignore its influence. This, as I have tried to make evident, is impossible, if not on æsthetic grounds, then on

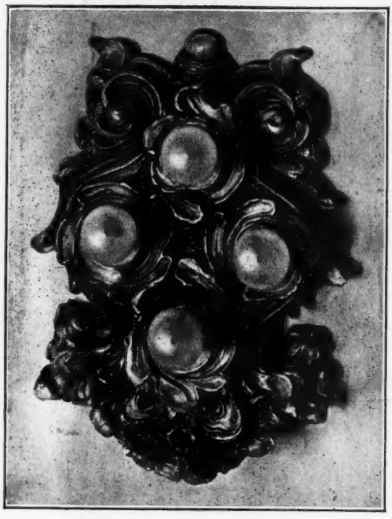


FIG. 6.—Example of Illegitimate Use of Ornament.

physiological grounds, and to deny its demands would be suicidal. "Habit," says James, "is the great fly-wheel of Society." Any sudden alteration in its movement would only serve to smash the whole machine. Change can only be brought about by infinitesimal alterations in its progress. The illuminating engineer who imagines that he will be permitted to introduce anything radically new into the illumination of buildings possessing historic feeling, is doomed to disappointment. Rather is it his duty to maintain and conserve that feeling in spite of modern appliances and means.

(34) The "feeling" of the design must be carried out consistently even to the last detail of the fixtures. It is the duty of the architect to see that this is done. His conception of the whole arrangement must include the lighting, for as he sees it "in his mind's eye" so must it be seen objectively. The light that must be provided, its tone, its intensity, its quality, is a feature of his mental conception, and it is this ideal illumination that the engineer must seek to approximate. Of course, he can only hope to do this when he, too, is able to see the design as the architect sees it, and not through the eyes of the illuminating specialist alone. The engineer must be able to discern where direct or indirect illumination is required, and the kind of fixtures associated historically and æsthetically with the general design, by means of which he must obtain the proper results. For instance, examine Figs. 7 and 8. Note the absolute harmony both in proportion and detail, denoting throughout the expression of a single ideal. No other scheme of illumination, and no other style or type of fixture could have been used without marring the entire effect. Such illumination is good illumination. The resulting distribution may not be perfect from the engineer's standpoint—but then his standpoint is itself imperfect if he fails to consider just the limitations imposed upon him by the design. Illuminating engineering is not a matter of light distribution—it is a matter of suitable lighting, and the conditions determining what is suitable are just as different as any two designs are different—no more, no less. Does the architect consider a building unsuccessful unless each part of it is laid out according to the laws of construction? Not a bit of it! The laws of construction are an after consideration—a means of checking the proportion to see if, after all, it is safe. So, too, the illuminating engineer must use the laws of distribution, not as a method of determining what the distribution shall be, but as a means of adapting the lamps to the distribution required. It is not a question of foot-candles; it is a question of how much light is needed. And it is more often a question of quality than quantity.

(35) You will say that foot-candles and quantity of light are one and the same thing, but I assure you, that from the architect's point of view, they are quite different. Two lamps giving an identical quantity of light may give entirely different quantities of illumination. The room shown in Fig. 9 is furnished with a very small quantity of light, but with ample illumination. The same quantity of light, if used in Fig. 7, assuming the rooms to be of the same



FIG. 7.—Salon des Gardes, Grand Trianon.



FIG. 8.—Salle à Manger, Grand Trianon.

general dimensions, would give practically no illumination, even if the general coefficients of reflection were in both cases identical. For what we see is, as the early part of this paper sought to make clear, not only what our optical nerves bring to the visual centres, but, in addition, a vast amount of suggestive material aroused to consciousness through the associative brain tracks.

(36) This associative material, with the actual sensory matter, together make up the perception which is conceived as an idea. The idea tends to find itself realized or embodied objectively, and this tendency toward the habitual or normal, conversion of the idea, is sentiment. In art, sentiment is defined objectively as the "feeling" of the design, and where the sentiment is not realized we say that the design is out of keeping, and, in so far, defective.

(37) How, then, is the illuminating engineer successfully to cope with his problem and advise with the architect as to the best means of achieving results, if the engineer cannot appreciate and understand the architect's viewpoint? Manifestly it is impossible for him to do so.

(38) It seems, then, that a very important, if not essential, feature of the engineer's preparation is a study of the history of illumination and its relation to architectural design. He must make himself intimately acquainted with the means, methods, and results of earlier work—and good work it is—where any attempts were made to obtain adequate and suitable lighting. We must not think, because we alone can formulate and employ the laws governing the distribution of light, that good lighting has not been earlier achieved by empirical methods. We are simply in a position to do more efficiently what the masters have done in spite of their manifest limitations.

(39) This branch of illuminating engineering is unquestionably an art, and only a science in so far as an art is scientific in its method. The illuminating engineer, who hopes to cope with the lighting features of architectural problems, must be familiar with architecture, and particularly with the use of colour in decoration; for, as we well know, the æsthetic value of colour arrangements depends on extreme nicety of contrast, and colour contrast is very susceptible to variations in tone and intensity of light, particularly at the low intensities very generally desirable from an artistic standpoint.

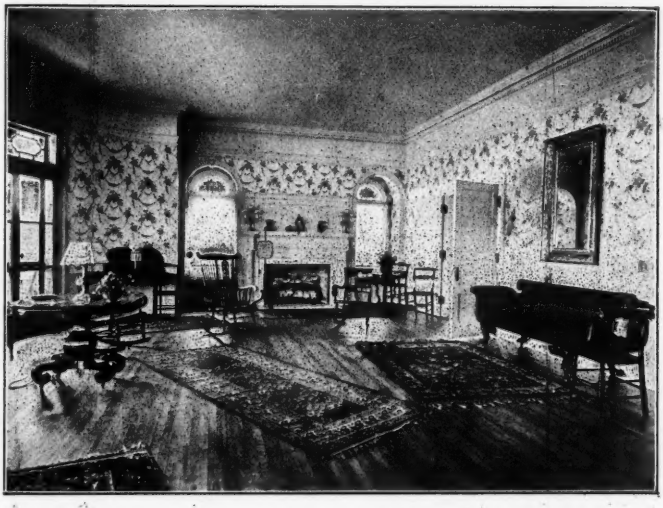


FIG. 9.—A Colonial Room. Note that a Centre Ceiling Fixture would Ruin the Effect.

(40) The question as to the proper location and arrangement of fixtures, then, resolves itself into the question as to the way in which the design is to be seen. The proportions of the structure, its constructive lines and the points where they originate and end—these are to be brought out in relative prominence,

and to do this properly the individual responsible for the lighting must be able to discern and select these features and modify his illumination accordingly.

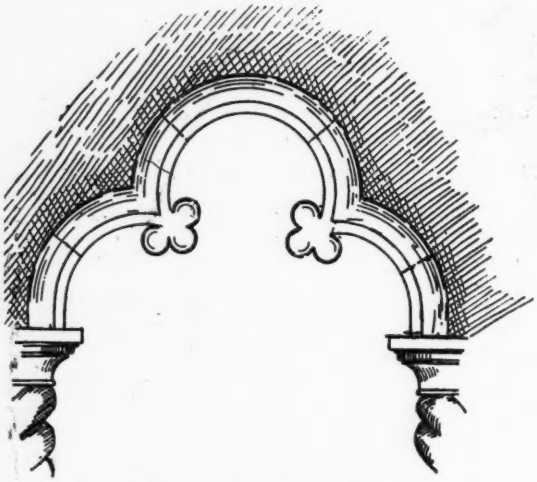


FIG. 10.—Trefoil Gothic Arch.

Take as an example the trefoil Gothic arch shown in Fig. 10. This, we will assume, by its importance in the structure, requires to be seen in its entirety. It is not sufficient that one segment, or even the two lower segments, be brought into prominence. It is demanded by the nature of the problem that the light so fall upon it that the eye shall be capable of tracing its outline from one abutment to the other, and if this cannot be done there will result a feeling of insecurity and of incompleteness. The problem, then, becomes one of so locating the lights that this result be accomplished.....

An example of the illumination of ornament is shown in Fig. 11. Suppose it is desired to place a single lamp at the centre of the relief ornament used to decorate the opening of a small arch, such as might be found in the dome of a rotunda.

(42) If the rotunda is to achieve its full effect, its decoration must be brought into prominence, and to accomplish this the lamp must be so located that, in addition to its work of furnishing light to the space below, it will bring out the principal generating lines of the decorative relief, that is, the ridges of the cockle in this particular example. In other words, the curve A—A—C of each member must be thoroughly lighted for its entire length. The architect, if he is alive to the necessities of the problem, will have allowed for this feature by giving a concave form to the ornament, and by deepening the space between it and the arch line.....The architect must allow for these requirements in his design. It is, in fact, impossible properly to light a design that has not been conceived as illuminated and suitably adapted therefor....

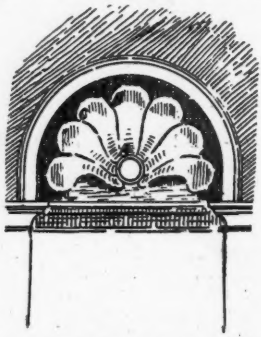


FIG. 11.—Example of the Illumination of Ornament.

Historic Precedent in Illumination.

In this section of the paper the author traces the development of lighting-fixtures from the old Roman lamps, drip-

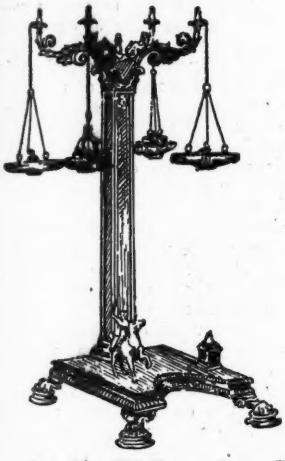


FIG. 12.—Old Roman Lamp Bearer.

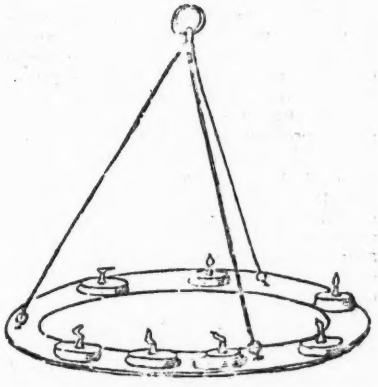


FIG. 13.—Form of Lighting Fixture Used in Early Christian Basilicas.

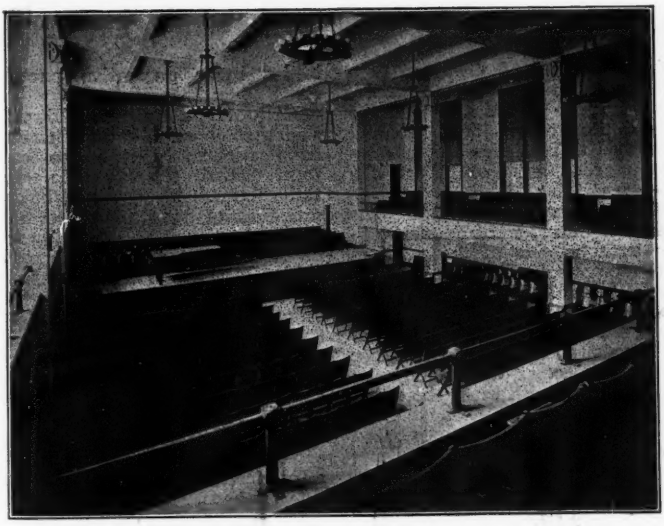


FIG. 14.—Adaptation of Fixture Shown in Fig. 13 to Modern Methods.

saucers, &c. Such lamps were often exquisite in design, but yielded a comparatively poor illumination.

But in ancient times, and in Roman and Gothic churches, very little artificial illumination was provided. Churches were rarely used at night, and reading in church was regarded as unnecessary. The lighting fixtures in historic English churches are chiefly of recent date, and many of them are inappropriate.

The author sums up the difficulties of the problem in section (50) as follows:

(50) A study of the history of church lighting will make one fact evident. The palpable artificiality of every kind of illumination presents an almost insurmountable difficulty. It is practically impossible to design any adequate system that would not seem totally out of place in such interiors as that of Durham and Amiens and the earlier portions of Canterbury or Westminster Cathedrals. The architecture of these great edifices makes its appeal purely through the sublimity of its proportions. Decoration and ornament are unnecessary, and have been but sparingly used. To attempt to light these buildings by any means less impressive in its effect than they are themselves would be little short of desecration, and artificial illumination is essentially decorative in its results. It may, in general, be taken as a rule that the simpler the architecture—provided it be good architecture—the more difficult becomes the problem of illumination.

(51) It is only by such historical study that we can learn the nature of the ideal which the great masters of architecture sought to embody in their work, and only as we succeed in making this ideal our own, can we hope to express, in our efforts, the truth of architectural beauty.

PHYSIOLOGICAL.

(52) This paper has carefully avoided any discussion of the physiological effects of artificial illumination, for it is the writer's belief that no architectural design, conceived in the right spirit, and properly executed, can demand any suitable artificial illumination that is injurious in the optical sense. The reasons for this lie deeper than the physiology of the eye can lead us, and have to do also with visual perception and psychology. It is a subject demanding separate treatment, and cannot be encroached upon in this discussion. Artistic illumination is, *ipso facto*, good illumination; and no illumination can be artistic that is not conceived as a feature of a truly artistic design.

DISCUSSION.

THE CHAIRMAN (E. L. ELLIOTT) expressed his sense of the value of the paper. There was no denying the importance of these questions of taste, which could not be reduced to mathematical calculation, and afforded great scope for discussion.

L. B. MARKS hardly agreed that the illuminating engineer, who did not consider the æsthetic side of the problem besides the practical side, was doomed to ultimate failure. There were many cases in which these æsthetic aspects were of secondary importance, and under these conditions the illuminating engineer might achieve success, even though he were not concerned with the artistic side of his work.

Mr. Jones had stated that the mind instinctively asks, "What is a thing for?" Surely lighting fixtures are intended primarily to illuminate—to enable us to see—and no amount of grace or ornament can make up for their failure to do so.

In a fixture intended to give useful light rather than decorative effects, engineering should take precedence of æsthetics in design, whereas in a fixture intended for decorative purposes this order might be reversed.

Mr. Jones, referring to Figs. 7 and 8, said that no other style of fixture would have adequately met the conditions. Apart from the æsthetic standpoint these fixtures left much to be desired as producers of good and uniform illumination. For instance, according to Fig. 8, an observer viewing the pictures at short range might find himself between the light and the picture, while at longer range the light would strike his eye at an inconvenient angle.

Mr. Jones maintained that adequate illumination was not a matter of foot-candles, and that quality, rather than quantity, was often needed.

The illuminating engineer, however, ought to assist the architect to secure a particular effect by exact and scientific methods. The study of illumination leads to definite and accurate methods of producing results hitherto only obtained in an empirical manner.

In the same way, if it were true that "it is, in fact, impossible properly to illuminate a design that has not been conceived as illuminated and adapted

therefor," co-operation between the architect and the illuminating engineer was all the more essential. The position of the architect a generation or so ago was very different from at present. To-day he has many illuminants to consider, and has at his command new means of directing and distributing the light previously unknown.

S. W. JONES thought that the illuminating engineer should be free to illuminate buildings in which æsthetic and historical principles were not of paramount importance. But in cases in which this last point of view was of consequence the architect was best fitted to deal with the problem.

W. S. KELLOG referred to the inartistic nature of many existing fittings. It was very essential that architects should be free to exercise a rather arbitrary control of the decoration of buildings under their charge. Otherwise each individual contributing to the scheme would insist on his own views being recognized, and chaos would result.

He agreed that the business of illuminating engineers was to modernize old methods of illumination without destroying them.

"Softness" of light was very desirable, and the present 16 candle-power lamp was too high a unit. Many people were wearing glasses as a result of our abuse of modern improvements in lighting. The speaker had recently received complaints of poor lighting in a recently erected building. Knowing the lamps provided to be ample, he was disposed to laugh at them, until he discovered that a type of reflector and fixture had been adopted that produced a perfect glare of light. The users suffered, not from too little light, but from too great intrinsic brilliancy.

In the case of the rooms described by Mr. Jones in paragraph 34, the illumination was, of course, intended to show off the decorative scheme to the best advantage—not to permit the easy reading of a newspaper. Engineers were too apt to insist upon mere efficiency, without considering the countless other factors in the problem.

V. R. LANSINGH appreciated the ideas expressed by Mr. Jones and Mr. Kellog, and quite agreed that the lighting of a room should be in keeping with the purpose for which it was intended. At the same time he felt that architects ought to be familiar with the principles of illumination, and that the illuminating engineer could often be of service, even in cases where æsthetic principles were of paramount importance. Both the architect and the illuminating engineer might learn much by trying to understand their mutual points of view.

A. J. MARSHALL quite agreed that illuminating engineers ought to be acquainted with the æsthetic sides of the problem, but thought it was a mistake to suppose that there are no members of the illuminating engineering profession capable of appreciating beautiful things, though, of course, there might not yet be as many as was desirable.

G. H. STICKNEY likewise appreciated the need for co-operation between the architect and the engineer. In particular, he thought it very essential that engineers should exercise caution in applying the data at their disposal. The conditions of daylight illumination had considerably influenced the engineer's view of lighting problems, and being so much stronger, as a rule, than that produced by artificial means, sometimes led him to neglect historical standards.

MR. HOPKINS said that the fixture-designer and the manufacturer had been watching the progress of the illuminating engineer with great interest. It was the function of this expert to determine the power of light sources, decide their location and distribution, and generally accumulate data for the problem to be attacked. Only, in applying his data, he must realize the restriction imposed by the architect's design, and not apply indiscriminately the rules which guide him in the lighting of commercial buildings.

Mr. Hopkins also thought that in matters of lighting too sharp a line was often drawn between cost of maintenance and interest on investment. When a considerable sum of money had been expended on ornamentation and decoration of interiors it was short-sighted policy to grudge the addition of adequate illumination, and so jeopardize the return of pleasure to be derived from effects which the owner had been at such pains to secure.

Finally, Mr. Hopkins urged those present not to suppose that all fixture-designers—or nearly all—were indifferent to the claims of good illumination.

E. L. ELLIOTT remarked that the architect and the illuminating engineer met on a certain zone of neutral ground. On the other hand, the relative predominance of the two aspects of illumination in which they were respectively interested, naturally depended upon the variety of building to be illuminated. In many cases where a building served a purely utilitarian purpose the scheme of lighting might be left to the illuminating engineer. For instance, in the building

and lighting of a central station the work of the engineer naturally ought to take precedence over that of the architect, and no architectural considerations would be allowed to limit the requirements of efficiency and economy in operation. But in matters concerning the general æsthetic effect, both interior and exterior, the claims of the architect should take precedence. Yet even in many cases of this nature there need be no reason why the scheme of lighting should not be at once decorative and efficient.

Mr. Jones had explained that in regard to æsthetic features the mind instinctively asks, "What is the thing for?" He wished to apply this to the wall-bracket in Fig. 1. The eye followed the lines of the design with ease and comfort, and was led to suppose that the fixture was designed to carry a candle. But it was not; it was merely holding a clumsy and childish imitation of a candle, in the form of a piece of opal glass tubing surrounding an electric bulb lamp. This fixture therefore transgressed Mr. Jones's maxim, "Beauty is truth, and truth beauty."

In the same way it might be asked, "What is the use of the ring at the base of the design shown in Fig. 2?"

MR. JONES said it was a switch.

MR. ELLIOTT replied that it was a misplaced switch, and ought to have been on the side walls. The eye supplied no reason for its existence.

Mr. Elliott agreed that the illumination of a cathedral was certainly a difficult problem, but possibly a change of sentiment might simplify the existing difficulties. He did not agree with Mr. Jones, however, that in a massive building fixtures must be designed on a corresponding scale. It would be quite as logical to put legs 8 ft. high on tables and chairs for use in a room with a 40 ft. ceiling. Certainly this view was not upheld in ancient times, and the candelabras of ancient Greece and Rome, in spite of their exquisite workmanship, often bore no relation to the proportions of the buildings in which they were used. Again, the coronas in the early churches were delicate and well adapted to sustain their own weight, but never unnecessarily massive, in spite of the hugeness of the building. In every case the builder used the best light-sources then available, and did not attempt to imitate one light-source by another. We, to-day, ought likewise to take advantage of the improved means of illumination at our disposal.

In reply MR. BASSET JONES stated that the criticisms were very much what he anticipated.

In the first place, it might be admitted that there was work for the illuminating engineer in treating cases where the æsthetic considerations were of secondary importance, but if he confined himself to cases of this nature the scope of his work must be an ever narrowing one: civilization and interest in æsthetics moved forward simultaneously.

Certainly, as Mr. Marks and Mr. Elliott had said, a lighting fixture was intended to enable us to see, but it must also enable us to see with pleasure; this depended on the effect produced, and was not a mere matter of candle-feet. Similarly he held that usefulness was important, but that beauty was itself eminently "useful." Mr. Elliott had said that every object of utility must express a truth; but truth was not confined to the practical point of view, and a lighting-fixture did not justify its existence merely by giving a certain amount of light. In short, a lighting-fixture is only imperfectly useful if out of harmony with its surroundings.

The speaker agreed with Mr. Marks that the æsthetic value of the fixture shown in Fig. 1 would be lost if the lamps used were of too high brilliancy; but here, again, such brilliancy is not only unsatisfactory from the utilitarian standpoint, but also inartistic.

As regards the view of the Grand Trianon dining-room in Fig. 8, it might be remarked that this room was only a picture-gallery in so far as this palace had become a national museum. To disturb its form of lighting would be to rob it of historic interest. It was, however, unfortunate that the room should be used to exhibit objects of art, for it was not designed or adapted to this purpose. In the same way it might be admitted that if the Salon des Gardes, shown in Fig. 7, was used as a study instead of as a reception-room, it might have to be differently lighted; but this would entail a loss of that unity of design so essential in good architecture.

He did not agree with Mr. Elliott's criticism, based on the delicate work of some Gothic coronas. In these cases the lines of the building were also intended to furnish lightness of feeling rather than massive proportions, and therefore the light work referred to was in harmony with the whole.

Mr. Marks was quite correct in saying that the illuminating engineer ought to secure the desired effect by exact and scientific methods. It was this *effect*, and not the quantity of light, that was all-important. On the other hand, illuminating engineering had yet to furnish

data that could direct the ultimate determination of what was good and bad taste. It was the part of taste to furnish the illuminating engineer with data on which to work.

The architect naturally resented the attempt of the engineer to deal with duties he imperfectly understood, and the failure of the illuminating engineer to realize this point might do much harm to the profession as a whole. Nevertheless co-operation between both professions and a willingness to recognize each other's functions and point of view was extremely desirable. The architect had need of the illuminating engineer's advice, for the complexities in the means of illumination at his disposal were increasing daily.

Some such illuminants, however, were inadmissible on artistic grounds. Moreover, illumination that was not hygienically and physiologically correct must cause discomfort, and must therefore fail æsthetically.

Finally, the speaker disclaimed any intention of suggesting that engineers were necessarily inartistic. But it was important for engineers to appreciate the fact that in buildings of any artistic pretensions the purely engineering side of the problem must take a secondary position, and must be devoted to the economical production of the effects required by the design.

The Illumination of the Canals in Venice.

An interesting situation seems to have arisen in Venice in connexion with the proposal to replace the old flat-flame burners in that city by incandescent mantles.

The proposal has been very unfavourably received by many artists and others on the ground that the æsthetic value of many of the celebrated streets and waterways in Venice would be most prejudicially affected by the proposed innovation. At present these canals are but dimly lighted, and it is asserted that the artistic moonlight effects for which they are celebrated would be all but obliterated by the introduction of a uniformly brilliant illumination.

This seems to be just one of those cases in which the services are needed of an expert sufficiently broad-minded to perceive the claims of both the utilitarian and æsthetic aspects of the situation. Without wishing to convey the impression that the introduction of a useful standard of illumination is necessarily inartistic, one cannot but feel that in the present circumstances the æsthetic standpoint deserves special consideration, and that the incautious application of methods of lighting which are considered satisfactory in the case of an ordinary thoroughfare might justly be resented.

In street illumination, for instance, there are undoubtedly many cases in which other than purely utilitarian considerations must be taken into account.

We do not always desire merely to illuminate the pavement or the traffic. We are constantly erecting beautiful buildings in our streets, and we certainly ought not to ignore the possibility of so selecting and spacing illuminants as to show off their architectural features to the best advantage.

The question is one which is likely to frequently recur, in a less acute form, in this country. Every such problem involves special circumstances and demands attention at the hands of a man who is both willing and able to appreciate these two distinct, but not necessarily conflicting points of view.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

The Physiological Basis of Illumination.

By Dr. Louis Bell.

(From the *Proceedings* of the American Academy of Arts and Sciences, September, 1907, Vol. XLIII. No. 4.)

(*Continued from p.* 332.)

The human eye seems, however, to have become specialized for considerable acuity in a moderate light rather than for such extreme sensitiveness as is found in many nocturnal animals whose pupillary apertures vary over a much wider range than in man.

The curves of Fig. 1 show simple retinal sensitiveness, and in reckoning from them one must at low illuminations take account of the gain from increased aperture. At ordinary working values of the illumination the gain is small; but at 1 or 2 meter-candles it is very material, and plays a most important part in practical vision. For example, by curve *a*, Fig. 1, an illumination of 0·5 meter-candle would imply a value of Fechner's fraction of about 0·2, which would, in turn, imply very much impaired shade-perception. In point of fact, one can see quite tolerably by a candle at the equivalent distance of 1·4 meters.

For if the pupil has adjusted itself to this situation the virtual illumination is that corresponding to about 2 meter-candles, the equivalent area of the pupil having increased to at least four times its ordinary value, which is that to which the curves of Fig. 1 pertain. The result is a value of 0·1 or less for Fechner's fraction, which is quite another matter.

Were it not for this assistance, it would be quite impossible to get accurate photometric readings at the low intensities common upon the photometer screen. Similarly it would be exceeding difficult to get about at night, even by moonlight. In this latitude moonlight near full moon may fall to about 0·2 meter-candle, which would give Fechner's fraction at nearly ·5, barring aid from the iris. With this aid increasing the aperture perhaps 6 times, one can see to get about very easily, and can even read very large print. The same conditions have an important bearing on vision in presence of a strong radiant. For example, suppose that in a general illumination of 1 meter-candle one can make out objects having a contrast $\frac{dI}{I} = \cdot 15$. Then let a light giving 20 meter-candles come fairly into the field of vision without materially illuminating these objects. The pupil will close to about one-third its former area, giving a virtual illumination of about 0·3 meter-candles and a shade-perception of about ·30, in which, of course, the objects disappear. Hence one cannot see well across a bright light, and even objects illuminated by it lose in visibility, unless the change in illumination from them is greater than the concomitant change in aperture ratio.

The loss in visibility by the presence of a brilliant radiant in the field of view is increased by the change in adaptation of the eye. It is also probable that the intrinsic brilliancy of the radiant, as well as the light received from it, has a bearing on the pupillary aperture. Certainly at equal illuminations a well-shaded lamp gives higher visibility than a bare one, both being assumed to be in the field of view. There is therefore every reason for keeping such things as bare gas-lights and electric lamps entirely out of the visual field, only admitting them thereto when they are so shaded as to keep the intrinsic brilliancy to low limits.

The eye has been evolved under conditions that imply rather moderate intrinsic brilliancy, admitting the general desire to keep the direct rays of the sun out of one's eyes. Sky light, of course, varies very widely in apparent intensity, being most intense in the presence of white cloud of moderate density. An average all the year round mean for the northern part of the United States, giving the intrinsic brilliancy of an aperture fully exposed to the upper sky, would be, from

measurements by Dr. Basquin,* in the neighbourhood of 0·4 candle-power per square centimeter. This is lower than the intrinsic brilliancy of any flame, and approximates that of a bright lamp behind a thin opal shade. The ordinary window, which is in a wall rather than the roof, and gets its light largely from low altitudes, and somewhat reduced by trees or buildings, is much less brilliant.

For instance, a window 1 m. wide and 2 m. high would be unusually effective if it gave 50 meter-candles at a point 5 m. within the room. This illumination would imply a virtual intensity of about 1,250 candles at the window or an intrinsic brilliancy over the window area of 0·0625 candle-power per square centimeter. Natural intrinsic brilliancies are decidedly low, and the chief difference between natural and artificial illumination, from the standpoint of wear and tear upon the visual organs, is the high intrinsic brilliancy of artificial light. If radiants are to be within the field of vision, they should be screened by diffusing globes or shades down to a maximum intrinsic brilliancy of preferably not above 0·1 or 0·2 candle-power per square centimeter, certainly not above double these figures. As I have pointed out in a former paper,† if one plots the pupillary apertures as ordinates and the function $\frac{1}{\sqrt{I}}$ as abscissæ, the result is nearly a straight line, so that if one measures the visual usefulness u of a certain illumination I in terms of what one may call the *admittance* of the pupil, then approximately

$$u = c\sqrt{I},$$

assuming that I is within ordinary ranges of intensity; that is, the eye works most efficiently at moderate illumination. The adverse factors in lowering the illumination are the optical errors introduced by increase of pupillary aperture, and the general failure of shade-perception and acuity as the illumination falls below about 10 meter-candles. Spherical aberration and astigmatism increase rapidly at large apertures, so that definition of objects is much impaired. This, doubtless, plays its part in the failure of acuity in very poor light, although a more prominent fact is the increase of acuity as the eye is stopped down at illuminations considerably above the critical value at which the eye comes into normal working condition.

This critical value to which shade-perception, acuity, and pupillary reaction all point relates, it must be remembered, to the illumination received from the objects viewed considered as secondary light-sources. In too strong light thus received the eye is as seriously dazzled as if the source were a primary one, and the usual effects of after images and other evidences of retinal exhaustion and irritation at once appear. In very insufficient illumination there is failure to see contrast and detail, and there is an instinctive effort to push the eye near to the object at the risk of straining the mechanism of accommodation seriously. The familiar success of this expedient opens up some of the most curious questions of physiological optics.

Suppose, for instance, that one is viewing white letters on a dark ground. Evidently the letter acts as a secondary source of illumination, which proceeds from it, following the law of inverse squares. Now by halving the distance to the eye the intensity at the pupil is quadrupled, and at first thought one would infer that inspection of the shade-perception and acuity curves would give ample reason for the gain in visibility. But at half the distance the object subtends double the visual angle, and the retinal image is therefore quadrupled in area, leaving the luminous energy per unit of area the same as before; why, therefore, any gain in visibility? A similar question in a more aggravated form arises in accounting for improved vision through night glasses.

The key to the situation is found in the fact, put on a sound experimental basis by Dr. Charpentier,* that for the visible brightness of objects giving images less than about 0·15 mm. in diameter the simple law of inverse squares holds. In other words, for weak stimuli at least, the visibility of small objects is determined by the total light emitted, and by the distance and not by the surface brilliancy. It is as if a retinal area of about 0·15 mm. diameter acted as a visual unit, all stimuli acting upon this as a whole. As Charpentier (*loc. cit.*) puts the case with reference to distance, "In a word, the apparent brightness of a luminous object varies, other things being equal and within the limits indicated, in inverse ratio with the square of its distance from the eye."

As the eye then approaches a luminous object its apparent brightness increases, and it is distinguished more plainly so long as its image dimenson is anywhere

* *The Illuminating Engineer* of New York Jan., 1907.

† *Trans.* Ill. Eng. Soc., July, 1906.

* 'La Lumière et les Couleurs,' p. 138 *et seq.*

within the limit mentioned. As this corresponds to an object 2 mm. long at a distance of about 20 cm., the rule holds for reading type and the observation of small objects generally. The cause of this phenomenon is somewhat obscure. The natural supposition that it might well be due to spherical aberration and faulty accommodation in an eye with its pupil expanded, fails, as Charpentier (*loc. cit.*) shows, in two ways. First, the circle of diffusion in the eye due to spherical aberration is much smaller than the critical diameter in this case, and second, the phenomenon occurs of the irradiation, but this seems to act in the main merely as a reduction of intensity, since the same effect is produced by a similar reduction in intensity by the wedge retaining the full aperture of about 5 mm. At a few hundredths of a meter-candle most of the irradiation has disappeared. The apparent breadth of the filament decreases without any marked shading off at the edges, something as if a slit were being closed. The appearances indicate that beside the undoubted aberrations which come into play, there is considerable spreading of light in the retina at high intensities

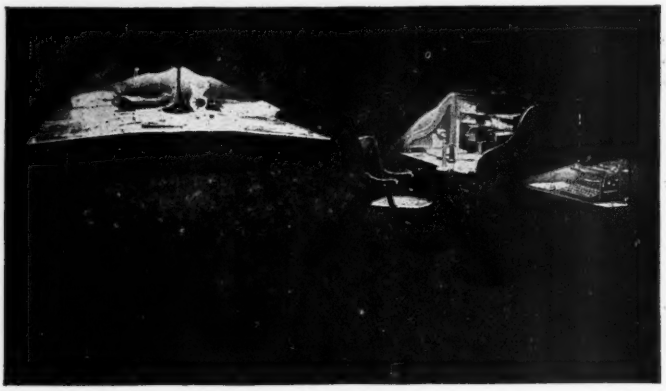


FIGURE 3.

when the eye is stopped by a diaphragm. I have tried it with a wedge photometer provided with a pair of 2 mm. apertures in line and separated by 6 mm., so that the ray pencil was of very narrow aperture, and find it still very conspicuous and apparently unchanged.

Charpentier and others are disposed to think its origin purely retinal, resulting from the spreading of the stimulus over retinal elements adjacent to those immediately concerned, and closely allied to the phenomenon of irradiation.

This latter phenomenon, however, is charged by Helmholtz largely to aberrations and dioptric faults generally. One of the best sources for studying irradiation is an incandescent lamp filament. At a distance of, say, 2 meters the apparent diameter of the filament at full incandescence is 4 or 5 mm. Using the wedge photometer upon it, the diminution of apparent diameter is at first rapid, until it falls to about 0·5 mm., at which it remains nearly constant until it completely vanishes. Stopping down the pencil of rays to 1 mm. or so cuts off most reinforced very likely by reflection from the choroid, producing an effect quite analogous to the halation observed in a photographic plate.

The dimensions of the irradiation effect thus observed are inferior to the dimensions required by Charpentier, but it is quite probable that with a dark-adapted eye and feeble illumination, lessened contrast with the chief image would render the outlying portions more conspicuous.

The increased visibility of rather large areas is a still more puzzling matter, for which no satisfactory explanation has been produced. Inasmuch as all dealings like these with threshold sensibility have by this condition eliminated the cones of the retina from action, and depend upon rod vision entirely, it may be, since the rods are relatively more numerous away from the fovea, that mere size of image insures its falling on retinal areas relatively rich in active visual elements.

Aside from questions of intensity in artificial illumination is the matter of

steadiness. It is, of course, well known that violent transitions of light and darkness, whether by moving the person or the eye, or by changing the intensity of the light itself, are distressing and injurious. The retina has a certain amount of visual inertia, which furnishes protection against very rapid changes, else one could not use lights successfully with alternating current. Flicker, from a practical standpoint, is troublesome and the frequency. With lamps of ordinary voltage and candle-power the flickering is perceptible at between 20 and 30 cycles per second, the new high-efficiency lamps being worse than the older ones. Practically all lighting is done at above 30 ~, and troublesome flickering comes only from the irregular fluctuations of bad service. It must not be forgotten that one can impress serious fluctuations of light on the retina

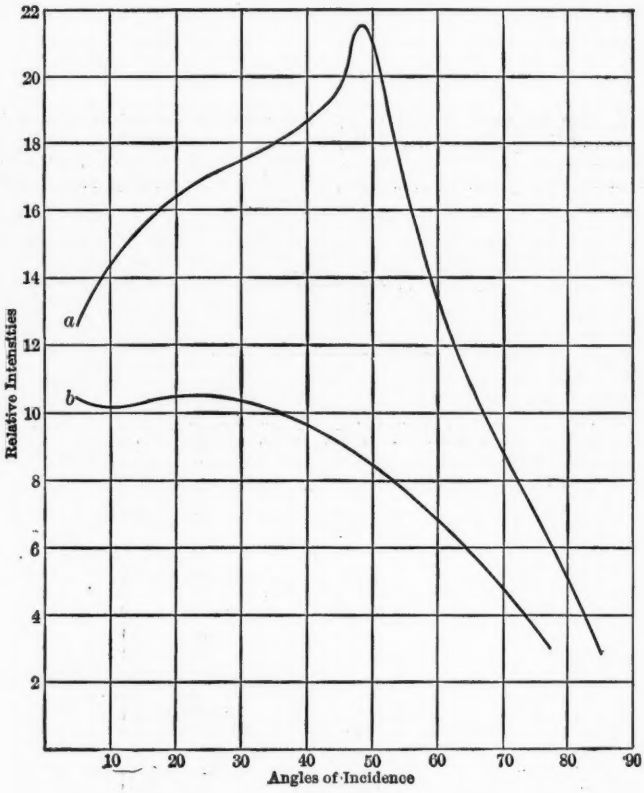


FIGURE 4.

about in direct proportion to its magnitude and in inverse proportion to its frequency. A change of intensity, however, covering some seconds, giving the iris plenty of time for readjustment, is hardly noticeable, while one of the same numerical magnitude, say 20 per cent. each side of the mean, occurring once or a few times per second, is most painful. Ordinary incandescent lamps run on alternating current vary from 5 to 15 per cent. on each side of the mean, according to the thermal inertia of the filament, by compelling the eye to confront great variations of illumination when it moves. No artificial light should be arranged so that it forces the eye to make sudden transitions from blackness to brilliancy. Fig. 3 is given here as a horrible example of what should never be permitted. I am sorry to say that it is from the catalogue of a maker of reflectors who should have known better. Note the blackness of the interior and the excessive brilliancy of the light on the work.

In this connexion should be mentioned

the trouble that may come from the glare of light reflected from white paper, a risk to which book-keepers are especially subject. I have been in counting rooms where I found every clerk with signs of bad eyes.

Much paper is too highly calendered, and from this cause gives a combination of regular and diffuse reflection. Obviously a mirror placed on one's desk would give at certain angles an image of the lamp of distressing brilliancy, and as the head might move this image would dodge into and out of the field of vision, giving an added cause of trouble. Glossy paper does somewhat the same thing. Fig. 4 shows from Trotter's data* the relative reflection at various angles of incidence from ordinary Bristol board (*a*), and from the nearly pure matt surface of freshly set plaster of Paris (*b*). The sharp peak corresponding to the angle of regular reflection is very striking. Light on a desk should therefore come from the side or rear rather than from the front, especially if the source is of high intrinsic brilliancy. For a similar reason the direction of illumination should be such as to free the eye from the effect of wavering shadows of the hand or head. The avoidance of shadow from the hand is the rationale of the sound old rule that the light should come from the left (left-handed people were forgotten). Shadows from the head and shoulders are much more troublesome, as they may exist to an annoying degree in rooms otherwise well lighted, and they are, in fact, difficult to avoid in the general lighting of counting rooms and similar places.

* *The Illuminating Engineer* of New York, 1, 488.

(To be continued.)

Colour Vision and Fatigue.

PROF. BURCH delivered a most interesting lecture on 'Colour Vision' before the Optical Society of London on April 7th. The lecture dealt briefly with the general physiological structure of the eye and then passed on to the main theories of colour vision, giving a résumé of some of his own experiments which have formed the subject of several communications to the Royal Society.

One of the most interesting points referred to, from the point of view of illumination, was the possibility of producing temporary artificial colour blindness by concentrating light of one particular colour on the retina. Thus the result of subjecting the eye to very intense red light is to produce fatigue for this colour, and so to cause red objects—brightly coloured geraniums, &c.—to appear dark in hue, or even black.

In Prof. Burch's own case the results of exposure to very strong monochromatic light were actually so severe as to affect one region of the retina for years afterwards.

An instructive experiment on this point was as follows. The audience were asked to close the left eye and, with the right eye open, to look steadily for a few seconds at some red coloured fire. Subsequently a yellow flame appeared very distinctly redder in tint to the unopened left eye than to the right eye, which had been fatigued by exposure to this red light.

Such experiments lead us to wonder whether the results of working under a new light of some peculiar colour for long intervals of time might not possibly prove injurious—might, for instance, as in the case of the Röntgen rays, lead to some ill-effect which only gradually makes its appearance.

One would also like to know definitely whether light of a given intensity of a certain colour is really more fatiguing in its action on the eye than another, and whether any appreciable difference in the action of ordinary illuminants could be ascribed to this cause. Moreover, if any such difference does exist one would naturally expect photometric readings to be influenced thereby. At present the influence of "fatigue" is often vaguely referred to as influential in photometric tests, but it is always difficult to form an exact conception of the exact nature of the source of error, the evil influence of which is feared.

Inverted Gas Lighting.

By M. C. WHITAKER.

(From the *Transactions* of the Illuminating Engineering Society, Dec. 1907.)

(*Continued from* p. 337.)

THE history of the modern inverted burner is confined almost entirely to the development of various systems of meeting the complicated conditions of inverted combustion; and a careful study of the difficulties and principles involved in the production of the most recent forms of inverted lamps will serve to show the trend of development.

Two general divisions may be made which involve the utilization of different principles of combustion.

The first is based on a burner calculated to pre-heat the gas or air, or the mixture; and the other is a type where the construction is so arranged as to avoid, as far as possible, increasing the temperature of the gases before they reach the point of combustion.

The advantage of pre-heating the gases before combustion is questionable, and prominent authorities may be quoted for and against the increased efficiency to be obtained by this method. From a theoretical standpoint it might be inferred that the incandescence of the mantle would be increased by raising the initial temperature of the gases before entering the combustion chamber, but practical results show conclusively that the abnormal rarefaction of the gases due to the increased temperature of the mixture tends to produce the opposite effect.

On the other hand, artificially cooling the gaseous mixture before combustion produces a decrease in the efficiency of the inverted lamp. Furthermore, the pre-heating or extreme cooling of the mixture necessarily complicates the construction of the burner.

Based upon these observations, inverted burner designers are usually adopting the medium system, and are constructing a burner so that the gaseous mixture will maintain a temperature ranging between the extremely hot gases produced in the regenerative type and the cold gases produced in the cooling type. The development in the art at the present time is largely based upon the adoption of the medium system.

In modern practice, inverted burner construction falls under three general designs:—

1. The upright Bunsen, with the tube carrying the gas and air mixture curved through half the arc of a circle.

2. The horizontal Bunsen tube, with the mixing chamber curved through one-quarter of an arc.

3. The vertical Bunsen, with a straight tube for the delivery of the mixture to the point of combustion.

Modifications of these designs are noted, in which the Bunsens are placed at various intermediate angles, but they are not in sufficient favour to be considered in a general classification. The prevailing types of inverted burners now on the market fall under these classifications.

In the study of the problems involved in the proper design, construction, and use of an inverted gas lamp, special consideration must be given to the following points:—

1. The production of a proper mixture of gas and air under all conditions of operation, so as to insure a perfect combustion.

2. Means for positively preventing flash backs under all conditions of operation.

3. Special construction of the Bunsen tube designed to project the gas and air mixture downward to the point of combustion with maximum velocity, thereby overcoming the ascending tendency of the mixture, due to its light specific gravity.

4. The elimination of gauzes, long and circuitous passages for the mixture, or any other features offering frictional resistance to the projection of the gases toward the point of combustion.

5. The protection of the fresh air supply from vitiation by the products of combustion.

6. Well designed and constructed adjustable gas check.

7. The effect of the corrosive action of the flame at the point of combustion; and the necessity of refractory construction at this point.

8. Good mantles.

9. Glassware and reflectors specially selected and adapted for effective and economical distribution of the light.

In the study of combustion as applied to the Bunsen burner we recognize three basic essentials—(*a*) the combustible, represented by the gas; (*b*) the supporter of combustion, represented by the oxygen of the air, and (*c*) the kindling temperature necessary to start the combustion, applied through the medium of a match or some other heating device. Eliminate any one or more of these three essentials and combustion ceases.

The combustion is the chemical union of the active constituents of the gas with the oxygen of the air, and the products of this combustion are definite chemical compounds in which the proportions never vary. Therefore, when a certain amount of gas is admitted to the mixing tube of the Bunsen burner, a certain definite amount of oxygen (air containing oxygen) must be entrained and mixed with it in order completely to consume the combustible constituents of the gas. If the air supply is insufficient to meet these requirements, unconsumed or partially consumed constituents of the gas will be discharged from the burner, either in the form of solid particles of carbon or as noxious gases.

On the other hand, an excess in the supply of air results in a great reduction in the incandescing power of the flame, and carries the mixture beyond the critical point, which may result in a "flash back."

It is the true function of a Bunsen burner to take in and mix with the gas in the mixing tube air containing the exact amount of oxygen required to consume all the combustible constitutents of the gas and convert these into inert, harmless products.

A Bunsen burner which meets these conditions derives the maximum heating value from the gas consumed and produces perfect combustion—both essential features in an efficient incandescent gas burner.

The working conditions of the upright burner are such that when the proper proportions of gas and air are once fixed perfect combustion will continue as long as the composition and pressure of the gas remain uniform. A perfect mixture in the Bunsen tube is indicated by the formation of the characteristic blue cone in the non-luminous flame. If the proportion of air is reduced beyond the proper point, the flame will change to the luminous variety, due to the incandescent particles of carbon. On the other hand, if the proportion of gas is reduced below the critical point, a flash back will result, unless prevented by the introduction of some mechanical appliance, such as a gauze.

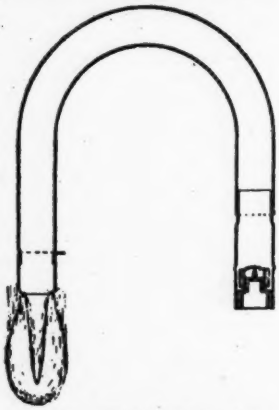


FIG. 3.—Sketch of Inverted Bunsen flame when first lighted.

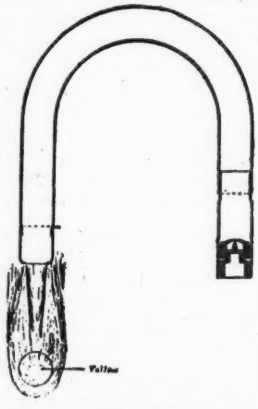


FIG. 4.—Sketch of Inverted Bunsen flame after ten minutes burning.

Having in mind the characteristics of a flame which indicate perfect combustion, a study of the form of flame produced by the elementary inverted Bunsen burner shows that a new condition is introduced in this form of lamp. When the simple form of inverted burner is lighted, and the gas and air proportions adjusted for the formation of a flame indicating perfect combustion (Fig. 3), it is observed that the characteristic non-luminous flame gradually changes, as the burner becomes heated, to a longer and more luminous flame (Fig. 4), indicating that

the proportions of the mixture have been changed by the reduction of the quantity of air entrained by the mixer. Inasmuch as this change does not take place until the burner tube becomes heated, it is safe to conclude that the modification in the proportions of the mixture is due to the rarefaction of the gases by the heat in the mixing tube, which prevents the aeration of the mixture in the same proportions as when the burner is cold. On the other hand, if the gas and air mixture is adjusted while the burner is hot, it is found that on relighting the burner, after it has thoroughly cooled, the proportion of air exceeds the critical point and the burner will flash back, unless prevented by some mechanical means; and, even if the flash back is prevented, the over-aeration materially reduces the mantle incandescence.

These observations established in the minds of the early investigators of this subject the idea of so constructing a burner as to regulate mechanically the amount of air admitted to the burner and to govern this mechanical regulation automatically by means of the heat developed by the burner. In other words, to utilize the heat which was the cause of the change in the composition of the mixture automatically to readjust the mixture to meet the requirements of perfect combustion.

It is obvious that the users of an inverted burner cannot be expected to readjust the lamp every time it is lighted, and to wait until it is thoroughly heated in order to put on the finishing touches of a proper adjustment. An automatic compensating device which permits of the burner being properly adjusted when first lighted, and which will gradually increase its air-entraining capacity as it becomes more heated from its own combustion, is obviously a feature upon which depends the success of the inverted incandescent gas burner.

Face to face with the positive necessity for this automatic compensating device, the situation is met by the invention of an attachment technically known as a "thermostat." The operation of the thermostat depends upon the fact that it is constructed from two pieces of metal possessing different coefficients of expansion when heated, and which are rolled together to form a single sheet. The thermostat, as applied to the inverted burner, is made by the formation of a slitted cone from a small sheet of this metal. It is placed in the mixing chamber of the lamp in such a position as to be protected from the corrosive action of the burning gases, and at the same time within range of the heat due to the combustion. When the mixing tube becomes heated, the fingers of the thermostatic cone open for the unobstructed flow of the gas and air mixture as long as the tube remains heated; when the light is extinguished and allowed to cool, the thermostat automatically assumes the conical form.

By maintaining the proper relations between the size of the mixing chamber and the dimensions of the thermostatic cone, it will be found that when the burner is cold the closed fingers of the thermostat interpose a sufficient amount of resistance to the entraining capacity of the mixing tube to prevent over-aeration. As the tube becomes heated and the thermostatic fingers open, this resistance is removed at a proper rate to compensate exactly for the reduced entraining capacity occasioned by the gradual heating of the tube. Figure 5 is a sketch of the flame of a burner containing the thermostat, showing the form at the moment of lighting; and Figure 6 shows the same flame after the burner has been lighted some time and has become thoroughly heated.

The fact that the flame in a thermostatically controlled burner remains practically uniform throughout the change from the cold to the heated state, establishes beyond question the practical value of this device for automatically controlling the gas and air mixture for the production of perfect combustion in the inverted burner.

The direct cause of a flash back is an explosive action which carries the flame into the mixing tube and sets up combustion at the gas orifice. This explosive action occurs in several ways, the common cause being the existence of an over-aerated mixture in the burner tube. It sometimes occurs, on lighting an incandescent gas burner, that an explosion takes place in the glass chimney or globe with such force as to drive the flame back into the mixing tube of the burner. The usual method used for overcoming the tendency to flash back is that of placing a gauze in the burner tube at or near the point of combustion. This gauze serves to maintain the mixed gases in the burner tube at a temperature somewhat below the kindling temperature, and thereby prevents a flash back. This will be recognized as the principle involved in the safety lamp invented by Sir Humphrey Davy.

The use of the gauze in the inverted burner for the purpose of preventing "flash backs" is objectionable on the ground that it obstructs and materially

retards the downward projection of the mixture in the burner tube, thereby defeating the object aimed at in the construction of an efficient Bunsen gas projector—an essential device to meet all conditions in operating a Bunsen flame in the inverted position.

Furthermore, the gauze acts as a sieve, collecting dust and lint entrained at the air ports of the Bunsen, and unless cleaned or renewed at frequent intervals will render the burner unfit for use.

An alternative method for overcoming the flash back is that of adjusting the air supply at the Bunsen ports so as to keep the mixture safely above the critical point at which a flash back occurs. Inasmuch as this critical point is very near the desired mixture for perfect combustion, there is great danger of reducing the air supply to a point which will result in discharging imperfectly consumed products. Furthermore, in view of the conditions explained under the heading of combustion, it should be noted that the gradual reduction of the air-entraining capacity, due to the heat of the mixing tube in the inverted burner, will further aggravate this danger.

That the relation between the cause of the flash back and the production of a proper mixture for perfect combustion is close is established not only upon the theoretical consideration of the conditions involved, but by the fact that the thermostatic cone introduced into the tube for the primary purpose of automatically adjusting the combustible mixture also prevents flash backs. Its operation is made doubly secure because its construction enables it to fulfil the function of a gauze, utilizing the principle involved in the Davy lamp, and also from the fact that it maintains the gas and air mixture throughout the entire operation of the lamp in a proportion which keeps it well within the critical limits.

In fulfilling the function of a gauze, the thermostat does not introduce any of its objectionable features, as the automatic movements of its fingers prevent it from collecting dust and lint. Furthermore, it is open during the operation of the lamp, and is removed completely from the pathway of the combustible mixture, and therefore does not offer any resistance to the passage of the gases projected from the raceway.

The Bunsen tube, even in the highly developed form now used in upright burners, fails in some essential features when applied to the inverted burner. In considering this problem, it should be noted that the ordinary illuminating gases are lighter than the air, and possess a marked ascending tendency even at the normal temperature. When considered in connexion with the heated condition of the inverted mixing tube between the gas orifice and the point of combustion, it is seen that this ascending tendency is thereby greatly increased.



FIG. 5.—Sketch of Inverted Bunsen flame when first lighted, thermostatically controlled.



FIG. 6.—Sketch of Inverted Bunsen flame after burning ten minutes thermostatically controlled.

The method used for overcoming the ascending tendency of the mixture is to project it downward with sufficient velocity to carry to the point of combustion.

The only force available for projecting the mixture downward is that obtained from the velocity of the gas at the check orifice. When it is considered that in many cases the initial gas pressure is very low, thereby greatly reducing the available force, and also that a certain portion of this force must be given to entraining the air for the mixture, it is obvious that great importance attaches to the production of a highly efficient Bunsen projector. The problem of construction involved is comparable to that arising in the designing of syphons or injectors used in moving liquids. In these devices it is well known that the efficiency depends not only upon the available driving force, but also upon the dimensions of the raceways, nozzles, and ports, and the careful adjustment of their relations to each other. With gases, these relations have to be more carefully worked out than with liquids, and no device in inverted burner construction has received more careful study than the proper and efficient Bunsen projector.

In the elementary forms of inverted lamps the projector feature is ignored and a plain tube of uniform diameter is used. While this construction serves as well as could be expected, when the operating conditions are uniform and within certain favourable limits, it fails utterly to meet the requirements of universal application.

To meet the conditions of varying composition and pressure, or uniformly low pressure in the gas supply, a construction is required embodying all the features of a highly efficient projector for gases. This requires an adjustable check which will give the greatest jet velocity to the gas as it is admitted to the Bunsen; air ports properly placed to give the most efficient entraining capacity; a "raceway" of correct diameter and length, to give the mixed gases the velocity necessary to carry them through the mixing chamber and to the point of combustion; a complete elimination of all features which would tend to reduce, by friction, the velocity of the projected mixture, such as gauzes, long or curved mixing tubes, &c.

An adjustable gas check is an essential feature of an inverted burner, in order to meet the conditions of varying compositions and pressures in the gases supplied for illumination. This is especially true in the construction of a burner for universal distribution in territories using different kinds of gas—coal gas, water gas, or natural gas.

While the primary purpose of the adjustable check is to regulate the gas consumption of the burner so as to develop its highest efficiency, it will be found that the design and construction of this device has a very important bearing on the continued successful operation of the light.

The velocity of the gas as it issues from the check orifice gives the force which entrains the air at the Bunsen ports, mixes this air with the gas to form the combustible mixture, and projects this mixture through the raceway and mixing chamber to the point of combustion. This requires a construction embodying the best known principles of efficiency to obtain the maximum velocity in the jet of gas as it issues from the orifice.

The most satisfactory construction to meet the requirements of the inverted burner is the single-hole check, controlled by the sliding needle. Great care must be given to the details of construction, such as determination of the proper size of hole to pass the required amount of gas at minimum pressure; the thickness of the check plate; accurate drilling, to insure the discharge of the jet into the centre of the raceway; and an adjusting needle which registers perfectly, to avoid deflecting the jet and thereby destroying the force of the discharge from the orifice. The adjusting screw should be easily accessible and headed with some non-conductor of heat to facilitate adjustment.

The protection of the fresh air supply for the inverted burner is a simple problem in mechanical construction; yet this matter has not received, in many instances, the care which its importance warrants. In the best types, a form of deflecting shield is incorporated in the general design to serve the multiple function of protecting the fresh air supply from vitiation, deflecting the products of combustion from the fixture arms, and safeguarding the adjusting screws from undue heating.

Another very important point in construction is the method used to prevent corrosive oxidation of the burner at the point of combustion. Metal tips have been found highly unsatisfactory in operation, and experience proves that the use of a refractory magnesia tip at the point of combustion is a well-justified addition to the first cost of the burner.

A New Form of Reflector for Street Lighting.

THE problem of street-illumination presents several peculiar difficulties, not the elast of these arising from the fact that it is essential to illuminate a wide area of road and pavement without dazzling the eyes of pedestrians. A new form of holophane reflector has recently been described, which is specially intended for street-lighting, and is said to overcome this difficulty very effectually.

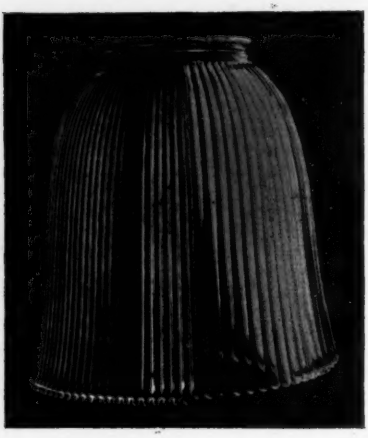


FIG. 1.

The general nature of this reflector will be understood from Fig. 1. This consists essentially of two distinct portions, a face and a back. The face, *i.e.*, that portion that faces the street proper, has a smooth exterior surface, with vertical totally reflecting and refracting prisms on the interior. The back, on the other hand, which is presented to the side wall, has a series of vertical totally reflecting prisms on the exterior and a smooth interior. It is claimed that these prisms, being vertical, do not afford an easy resting-place for dust, and, in addition, are partially cleansed by falling rain.

The distribution of light from the fixture is illustrated by Figs. 2 and 3. Fig. 2 refers to a 40 candle-power gem lamp, equipped with this reflector, and represents the intensity in a plane 10 degrees below the horizontal. The zero polar co-ordinate represents a plane at right angles to the line of the pavement, and it will be seen that the greatest intensity occurs in a plane at 65 degrees to this direction. As a result the strongest light is not thrown past obstructions that line the curb in the form of trees, posts, &c. The comparatively

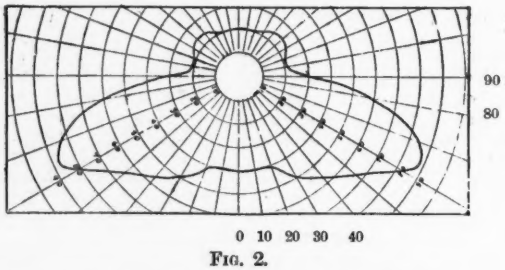


FIG. 2.

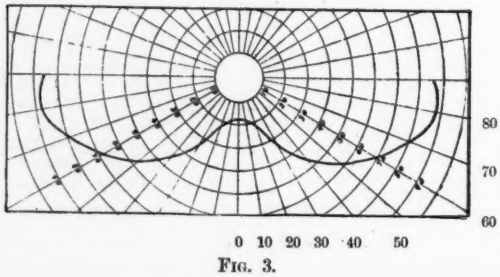


FIG. 3.

small amount of light thrown on the pavement is amply sufficient to illuminate it without distressing the eye. This is also secured very effectually by the



FIG. 4.

softening and diffusing action of the reflector.

This diffusing action should mitigate the objection of those who naturally dislike having a high power illuminant of great intrinsic brilliancy in front of their houses.

Fig. 3 represents the distribution of intensity of light in a vertical plane

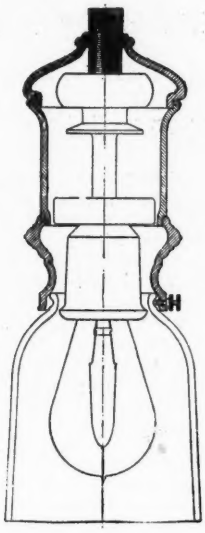


FIG. 5

through the 65 degrees ordinate of maximum candle-power shown in Fig. 2. Fig. 4 shows a suggestion for the application of the reflector in connexion with a conventional support, and Fig. 5 is a sectional drawing of the details of the arrangement.

The Brightness of the Sky.

BY E. KAHLER.

(*Metereolog. Zeitschrift*, February, 1908.)

THE author gives the results of a series of experiments having for their object the study of the intrinsic brilliancy of the sky under different metereological conditions, in its relation to the illumination of the interiors of buildings. He also works out relations by the aid of which the actual illumination under certain specified conditions can be predicted if the brightness of the effective region of the sky is known.

The brilliancy of the same part of the sky differs very greatly on different days, and, of course, the light derived from different regions of the sky also varies. It is not even possible to deduce any rigid connexion between the brightness at the zenith and at any other specified angle to the horizon, chiefly because of the widely different atmospheric conditions as regards clouds and mists that may prevail.

Electric Supply Prospects and Charges as Affected by Metallic Filament Lamps and Electric Heating.

By H. W. Handcock and A. H. Dykes, Members.

(Abstract of paper read before the Institution of Electrical Engineers, April 8th, 1908.)

It is very satisfactory at the moment to be able to induce a wavering possible consumer to decide in favour of electricity by pointing out that with the new metallic filament lamps two to three times the light can be obtained for the same current as compared with the ordinary carbon lamps which he has used hitherto.

But what will happen when every consumer uses high-efficiency lamps throughout? Can we feel sure that the only effect will be that the consumer will get more light, and will use as much as or more current than before?

Although the introduction of the gas mantle actually served to accustom people to a higher standard of illumination, it was nevertheless found that the consumption of gas per customer fell off considerably. In the same way the introduction of the inverted mantle has in some cases had an appreciable effect on the output of the works.

The present 110 volt tantalum or osram lamps, giving 23 to 30 candle-power at a consumption of 40 watts, although they have usually to be arranged in series, might appear to correspond very closely with the original gas-mantles in gas lighting.

In some cases consumers will be able to do with fewer points, and thus reduce their consumption. In others it will happen that they will improve their lighting, but not very greatly reduce their consumption. Some engineers seem to think the first state of affairs will predominate, whilst others incline to the latter. If metallic filament lamps were always to remain at the present price, and were only available in comparatively large units and at 100 volts, it is probable that the total effect on the station supplying principally private consumers would not be very marked.

The cost of the lamps—4*s.* for osrams and 2*s.* 9*d.* for tantalums—is a very considerable item, and consumers, therefore, will not adopt them to any great extent unless they can feel assured that their *total* lighting bill will be reduced, or, at any rate, not increased.

In the case of private consumers, where a large proportion of the points are single lights, with separate switches for each point, the saving in current, if any, with two lamps in series will, except where current is dear, not be great enough to ensure a general adoption of the lamps at present prices.

In the case of shops, halls, and factories, it generally happens that the lamps are mostly on all at once, so that the question as to whether a switch controls one or two lamps does not come in. The effect in this case, even if the same total number of lamps be used, is to decrease the current consumption by about one-third, with an increase in the illumination of 50 per cent. or more.

The total saving thus effected, after allowing for the increased cost of lamp renewals, depends on—

(*a*) The price charged for current.
(*b*) The price of the lamps.
(*c*) The life of the lamps.

The authors present, in this connexion, a very complete and useful table of the performances of tantalum and osram lamps of various intensities, as compared with an 8 candle-power carbon lamp, under different practical conditions. In most cases the use of a metallic filament, while enabling the consumer to save expense, causes a reduction in the current sold by the supply company of from 50 to 70 per cent.

Of course the metallic filament lamps have still several serious drawbacks, among which may be mentioned the liability of the lamps to breakage in transit, and the necessity for running two or more lamps in series on high pressures.

It is, however, common knowledge that even with the drawbacks above referred to, many large business consumers are putting in metallic filament

lamps, two in series, and many stations can testify to great reductions occasioned thereby in consumers' accounts. One thing is certain, that if a larger proportion of the total annual outlay on lighting is to be paid to the lamp-makers, the amount coming to the supply station must be considerably reduced if the total is to be reduced or even to remain the same.

If the consumption per consumer be reduced by, say, one-third, it is not sufficient to increase the number of consumers by 50 per cent., as this only just keeps the output at its former figure, without allowing for increased capital outlay on services, and increased expense in meter reading and general administration. It is, moreover, very doubtful if there are many districts where the number of consumers could be *quickly doubled*, whatever may be the result in the long run.

The foregoing remarks apply to those cases where 100-volt 25 to 30 candle-power lamps are used, two in series, on 200 volts or thereabouts.

The authors next refer to the use of transformers to reduce the supply pressure at the consumer's terminals to 25 volts or thereabouts. Their experience is very favourable. It may be objected that the transformer losses during the daytime would go far towards neutralizing the saving in current during the lighting hours. This difficulty may be obviated by keeping carbon filament lamps in the bedrooms, and arranging to switch off the transformers last thing at night, and then put them in circuit again, when the downstairs lights are again needed. There is now, however, on the market more than one switch which automatically switches the transformer off when the last lamp is turned off, and switches it on again when a lamp is turned on.

Under these circumstances we find that the consumption of current for the same illumination is only from one-third to one-half of what it was formerly.

In many cases—shops and business premises, for instance—the provision of a switch to turn off the transformer during the non-lighting hours presents no difficulty.

Since then these transformers have been made in large quantities, and it is quite evident that as soon as they become general the accounts of consumers on alternating current systems will be reduced by at least one-half.

Continuous current stations are not affected in the same way, but who can doubt that before long the price of metallic filament lamps will be largely reduced, and a satisfactory 200-volt lamp put on the market?

Such an event would largely increase the number of users of high-efficiency lamps and lead to a general reduction in lighting accounts. This will not affect so seriously the large companies in the manufacturing centres which have a large power load, and are able to supply lighting current at very low rates; but it will, we think, prove most serious for a large number of stations in residential districts dependent almost entirely on the supply of current for lighting.

What steps are the supply stations going to take to meet this? For some time to come it is hopeless to expect that the number of new consumers attracted by lower bills will keep the receipts up to the present level if the present rates and methods of charging be adhered to. Even in the case of the gas undertakings a severe check was received from the gas-mantle, and from the very nature of the business electrical stations are in a far worse position to withstand any reduction in receipts.

Taking the whole of the gas undertakings in the country, the Board of Trade returns are as follows:—

Total capital expenditure	£124,184,000
Total gross revenue ..	27,254,000
Total gross expenditure ..	20,496,000

For the electrical undertakings the figures are:—

Total capital expenditure	£50,767,000
Total gross revenue ..	6,514,000
Total gross expenditure ..	3,019,000

It will be thus seen that, whilst to obtain a gross revenue of £1 per annum a gas-works has to lay out £4 10*s.*, an electrical undertaking must spend £7 10*s.*; and, whilst the ratio of working expenses to receipts is 75 per cent. in the one case, in the other it is 46·3 per cent. This means, of course, that in a gas company a much smaller margin of receipts over working expenses is sufficient to pay interest and financial charges and profit on account of its smaller capital than is the case with an electrical company. An electrical undertaking requires a much greater margin between gross receipts and working expenses than a gas undertaking for two reasons:—

1. Because, as shown above, it has to pay interest on a much greater capital outlay per £1 of gross earnings.

2. Because, in addition to paying this interest, it is generally liable to be bought out for a nominal sum at the end of forty-two years, and has therefore also to provide out of the margin for a substantial sinking fund—a contingency that gas companies have not to meet.

The two causes, both disadvantageous *per se* to electrical supply, have really a cumulative effect, as an increase in the first increases the second. They also render loss of output a much more serious matter than to a gas company.

Speaking of the revenue to be derived from extending electrical supply to the smaller consumers, the authors state that, in their experience, this class of customer is not remunerative, especially when the cost of facilities of "free-wiring," slot-meters, services, &c., are borne in mind.

On the whole, therefore, while the consumer may expect to benefit from the introduction of metallic filament lamps, it is less certain whether the supply companies will derive any advantage.

If the consumer is to save money, and the lamp-maker to get a higher price for his lamps, is it unfair to ask that the supply station should get a higher price for its current, or, at any rate, that the present downward tendency in the price charged should be checked ?

The authors, therefore, remark that the time is opportune for a further consideration of the method of charging in the case of those electricity supply companies, a large proportion of whose current is sold for lighting purposes, to see whether by any rearrangement it is possible, without raising the price to the average profitable consumer, to make those contribute their fair proportion who at present do not do so, and also to encourage the use of current for various purposes beside lighting, thereby extending the hours over which the station's large capital expenditure is earning interest.

It is probable that nobody has done more to advance the electrical industry than Mr. Arthur Wright by his masterly exposition of the principles underlying the costs of electric supply. All interested in these matters are naturally familiar with Mr. Wright's papers on the subject, more especially the one read by him before the Institution in 1901.

The situation created by the introduction of metallic filaments only serves to lend additional force to the principles he then enunciated. Unfortunately, however, the public have not always realized the advantages that the use of the maximum demand indicator confers.

In many cases stations which formerly charged on the maximum demand system have now reverted to, or offer, as an alternative, the flat rate, not because the latter is a fair and equitable system, but because of the trouble in getting consumers to understand the theoretically more perfect one. In addition a lower rate is granted for current required for heating or power.

In this connexion the authors quote several examples to show how a difference in the charge for lighting and heating, or lighting and power, may lead to absurdities. A heated dinner plate or a private electric lift may be in use during peak hours, and yet be charged at the low rate.

According to the view taken by the authors, the only satisfactory system is one which is intermediate between the flate rate system of gas charging and the fixed rental of the water companies, in the same way that the conditions controlling the cost of supply are intermediate between those of gas and water; in other words, a fixed rental in addition to the charge per unit.

It will be noted that nearly every station has to give flat rates as an alternative, and also special rates for power. Indeed, many large stations, having abandoned the use of demand indicators and the maximum demand system of charging, get over the difficulty in a rough-and-ready sort of way by quoting each consumer a special flat rate depending on what they consider is likely to be the nature of his demand. The difficulty here is, of course, in making one consumer who is charged, say, 5*d*. per unit, understand why he should pay more than his neighbour, who, perhaps, has a smaller consumption, but is only charged 2*d*. per unit. This may work in a large London district where no one knows his neighbour, but it would be unworkable in a country town.

According to the existing legislation any consumer has the right by giving one month's notice in writing to require the undertakers to charge him by the actual amount of energy supplied to him.

The result of this is, of course, that if it pays a man to take a supply on any special system, he accepts it, whilst those at the other end of the scale who are unprofitable at a flat rate, but would be forced to pay more on a special system, naturally elect to pay a flat rate, so that any special system at a point where it would become advantageous to the company is defeated by the provisions of the Electric Lighting Acts.

Owing to the conditions that pertain, electricity, when in competition with gas, should be able to show a considerable advantage to long-hour consumers, while gas, on the other hand, should be able to supply very short-hour consumers at a profit where an electric supply company would possibly make a loss.

If electrical undertakings are to be helped at the present juncture by the extended use of current for power, cooking, and similar uses, in the same way that the gas stove and cooker came to the rescue of the gas companies, it is essential that the whole of the business be simplified. It must not be necessary to put in a separate meter, separate wiring, and to render two separate accounts, but, nevertheless, it is equally essential that current for power should not be sold for a low rate simply because it is for power, and the loss made good by lighting consumers.

The great majority of domestic heating appliances take a current of under 5 amperes, and it should be possible to attach any such piece of apparatus to any convenient plug on the general house wiring. The ordinary householder will not buy an electric kettle—he will not even use it if given to him free—if he has to pull the house about to put in special wiring and to pay 3*s.* per quarter for the rent of a second meter. Electric heating appliances could be put on the market much more cheaply than at present if the demand were greater, but there is little inducement to the makers to cheapen them under existing conditions.

The authors suggest that all the above difficulties, practical and theoretical, might be met if the present minimum charge authorized by the Board of Trade were made to depend on the maximum power with which any consumer should be entitled to be supplied.

A consumer is thus to pay a fixed sum yearly depending on his "contract demand," *i.e.*, an estimate of the greatest power he will probably require; this will probably be somewhat greater than his *mean* maximum demand, but less than its highest value.

This is illustrated by several numerical examples.

The question may be asked, How does the station know that any consumer will not exceed the demand he has contracted for? This, of course, rests with the judgment of the company, based on what they estimate their load factor to be. The authors, however, recommend the insertion in the consumer's house of a "limit indicator," the function of which is to throw a resistance into circuit, and thus indicate to the consumer, by a reduction in the brilliancy of his lamps, when he is exceeding his contract limit.

If the consumer thinks that his demand is not so high as the station engineer suggests, the latter will set the instrument to a lower limit, when the contract charge will be correspondingly reduced. In the event of the consumer having underestimated his contract demand, he will soon ask for his limit to be increased, when his account will automatically increase in the same way.

The point in which this method differs from the Wright system is that the consumer can determine his own maximum, and unless he asks for his limit to be raised, he knows within a little just exactly what his bill for current is to be. He cannot, as with the maximum demand system, inadvertently switch on a number of lights for an hour or so, with the result that he finds that he has a much higher bill than the previous quarter when he used the same number of units. That he had under these circumstances to pay a higher bill might be quite just, but it is precisely because the average consumer could not be got to see this, that the system, admirable as it is, has been given up in many districts.

On the new plan, if he exceeds his demand he knows it, and has either to reduce it or to apply to the station to have his limit indicator set higher, thereby acknowledging that his requirements are greater, and therefore should be paid for accordingly.

There is also every inducement to use radiators and cooking apparatus.

When an electric kettle can be brought as an ordinary article, taken home and plugged into any of the ordinary plug sockets, the demand will be such that the price will quickly come down and their use increase at compound interest rate, for as long as they are used in such a way as not to increase the load beyond the contract limit, the only charge will be the small one for so much additional current, in the case of the station above referred to, for instance, 0·95d. per unit. The contract rental will, of course, be regulated to suit the prevailing conditions, and include the ordinary meter rental, which will disappear. Special circuits and meters for heaters and motors will also be no longer necessary.

Although the authors consider the use of a limit indicator to be the best method of working the system, it can be dispensed with and the contract rental arbitrarily fixed by the station as is now being done in the case of varying flat rates, or an ordinary maximum demand indicator can be installed and the consumer informed that the contract rental will be so much, provided that the indicator does not show that the assumed contract demand has been exceeded at any period during the whole year.

REVIEWS OF BOOKS.

Der Eingeschlossene Lichtbogen bei Gleichstrom.

By Dr. Karl Stockhausen.

(*Published by J. A. Barth, Leipzig*, 1907.)

In this volume the author includes a description of his previous researches on the gaseous contents and the relation between candle-power and the amount of air admitted in the direct current enclosed arc-lamp. Besides detailing the results of specific researches, however, the author now includes a variety of information relating to the enclosed arc which will be found of exceptional interest.

Chap. i. contains a brief study of the existing literature and the historical development of the enclosed arc, including a short discussion of the arc from the standpoint of the ionic theory.

Chap. ii. deals mainly with the mechanical effects taking place within the globe; the author touches on the structure of the arc, and the possibility of the formation of a crater and the "wandering" of the arc round the carbons. Especially interesting are the results of investigations upon the temperature of the globe and a comparison of the same with that of other electric lamps.

The author also enters into the connexion between P.D., current, and arc-length, in the light of Mrs. Ayrton's results. He brings out the characteristic distinctions between the behaviour of the enclosed and the open arc, and states that the formulæ of Mrs. Ayrton only apply in the latter case, when the connexion between the apparent resistance and length of arc is a linear function. In the next chapter he refers to the chemical changes taking place within the lamp, especially with the view of explaining the explosion known to occur occasionally on striking the arc. He analyzes the contents of the globe under various conditions, and shows that an explosive mixture can occur; a considerable initial rise in the internal pressure may also follow the increase in temperature accompanying the striking of the arc.

The next chapter is concerned with the nature of the radiation, both in the visible and chemical regions of the spectrum of the enclosed arc-lamp. The sixth and last chapter is of a general character, and deals fully with the photometry of arc-lamps. The short discussion of the relative value of the contrast and the flicker photometer is interesting, though it must be recognized that the experience of a large number of observers on such a question as this is essential; it is therefore quite possible that many observers would not agree with the conclusions arrived at by the author. The full description of the Ulbricht globe and its application to the photometry of arc-lamps is exceptionally instructive, and is accompanied by several effective illustrations. Among other points discussed in this chapter we note the absorption of globes, the method of rating the candle-power of arc-lamps, and the connexion between the amount of air admitted to the globe and the light emitted. In the latter case the author arrives at the result that the intensity is appreciably increased by the admission of a small amount of air.

The book is written in a clear and interesting manner, and accompanied by useful references on the subject. The system adopted of summarizing the contents of important sections in order that the reader may see at a glance the essential conclusions arrived at, is worthy of special commendation.

The Junior Institution of Engineers.

Through the munificence of Mrs. Frank R. Durham a Bursary of the value of £25 per annum, to be called, after the Chairman of the Institution, the Durham Bursary, is about to be announced to the members and associates, of whom those between the age of 20 and 22 will be eligible to compete by writing a thesis on some technical subject chosen by the candidate. The first award will be made in October, and competing theses must be in the hands of the Secretary at 39, Victoria Street, Westminster, not later than September 1st next.

RECENT PAPERS ON ILLUMINATION IN THE UNITED STATES.

Summary of Papers Presented to the Illuminating Engineering Society.

(From *The Illuminating Engineer* of New York, March, 1908.

Fixture Design and Location. *Major E. L. Zalinski*	Dec., 1906
Fixture Location in Residence Lighting. *F. N. Olcott*	Dec., 1906
Application of Photometric Data to Indoor Illumination. *Ernest C. White*	Nov., 1906
Data on Indoor Illumination. *J. E. Woodwell*	Nov., 1906
Some Physiological Factors in Illumination and Photometry. *Dr. Louis Bell*	June, 1906
Method of Street Lighting by Incandescent Lamps. *Western Underwood and V. R. Lansingh*	May, 1906
Lighting of Streets by the Incandescent Mantle Burner System. *F. V. Westermaier*	May, 1906
High Efficiency Inc. Lamps for Street Lighting. *F. W. Willcox.*	May, 1906
Residence Lighting. *Jas. R. Cravath*	May, 1906
Notes on Interior Illumination. *Douglass Burnett*	Apr., 1906
Some Notes on Gas Illumination. *R. M. Searle*	Apr., 1906
Inverted Gas Mantle Lamps. *Victor A. Rettich*	Mar., 1906
The Luminous Arc Lamp. *E. L. Elliott*	Mar., 1906
Artificial Illumination from the Architect's Standpoint. *Waldo S. Kellogg*	Mar., 1906
Inaugural Address of President L. B. Marks	Feb., 1906
Light and Illumination. *Chas. P. Steinmetz*	Jan., 1907
Photometry of Incandescent Gas Lamps. *T. J. Litle, Jun.*	Feb., 1907
Progress of Electrical Illumination. *J. W. Cowles*	Feb., 1907
Aids to Progress in Lighting. *J. S. Codman*	Feb., 1907
Earlier Illumination and Photometry. *C. O. Bond*	Feb., 1907
Matters of Illumination which Affect the Eye. *Dr. Wendell Reber*	Feb., 1907
Residence Fixtures and Lighting. *R. C. Spencer*	Feb., 1907
Comparison of Methods of Office Illumination. *Edw. A. Norman*	Mar., 1907
Lighting of an Office Building. *Chas. M. Cohn*	Mar., 1907
Incandescent Gas Lamps. *T. J. Litle, Jun.*	Mar., 1907
Moore Tube System of Lighting. *H. E. Clifford*	Mar., 1907
Interior Illumination with Special Reference to the Meeting-Room. *T. J. Litle, Jun.*	Apr., 1907
Definition of Some Units Used in Electrical Engineering. *W. A. Evans*	
Industrial Plant Illumination. *George C. Keech*	May, 1907
Colour Values of Artificial Lamps. *G. H. Stickney*	May, 1907
Railway Car Lighting. *George C. Keech*	June, 1907
Schoolhouse Illumination. *B. B. Hatch*	June, 1907
Colour Values of Artificial Illuminants. *Bassett Jones, Jun.*	June, 1907
Prismatic Globes and Reflectors. *V. R. Lansingh*	June, 1907
Concepts and Terminology of Illuminating Engineering. *Clayton H. Sharp*	Oct., 1907
Primary, Secondary and Working Standards of Light. *Edward P. Hyde*	Oct., 1907
Illuminating Engineer and Central Station Practice. *Leon H. Sherck*	Oct., 1907
Illumination of the Engineering Societies Building, N.Y. *C. E. Knox*	Oct., 1907
Present Status of Candle-Power Standards for Gas. *C. H. Stone*	Oct., 1907
Inverted Gas Light. *T. J. Litle, Jun.*	Oct., 1907
Acetylene. *A. Cressy Morrison*	Oct., 1907
Acetylene Lighting. *Nelson Goodyear*	Oct., 1907
A New Comparison Photometer. *Chas. H. Williams*	Oct., 1907
Illumination Photometers and their Use. *Preston S. Millar*	Oct., 1907

Graphic Illumination Chart, A.	*Albert F. Parks*	Oct., 1907
Elements of Inefficiency in Diffused Lighting Systems.	*Preston S. Millar*	Oct., 1907
Electric Light as Related to Architecture.	*C. Howard Walker*	Oct., 1907
Illumination of the Building of the Edison Illuminating Company of Boston.	*Louis Bell, L. B. Marks, and W. D'A. Ryan*	Oct., 1907
What is Street Lighting?	*William H. Blood, Jun.*	Oct., 1907
Check on the Reliability of Photometric Curves.	*J. S. Codman*	Oct., 1907
Coefficients of Diffused Reflection.	*Dr. Louis Bell*	Oct., 1907
Metallic Flame Arc Lamp.	*C. E. Stephens*	Oct., 1907
New Lights and New Illuminants from the Central Stations Point of View.	*R. S. Hale*	Oct., 1907
Distribution of Light.	*Otto Foell*	Nov., 1907
Lighting of a Retail Store.	*F. J. Pearson*	Nov., 1907
Report of Committee Appointed by the New England Section to Investigate the Question of Standard Type for Photometric Reading		Nov., 1907
Fixture Design from the Standpoint of an Illuminating Engineer. Part Three.	*V. R. Lansingh and C. W. Heck*	Nov., 1907
Inverted Gas Lighting.	*M. C. Whitaker*	Dec., 1907
Fixture Designing.	*V. R. Lansingh and C. W. Heck*	Dec., 1907
Relation of Architectural Principles to Illuminating Engineering Practice.	*Bassett Jones, Jun.*	Jan., 1908
Variables of Illuminating Engineering.	*William L. Puffer*	Jan., 1908

A Summary of Recent Papers Presented to Various Technical Associations in the United States.

National Electric Light Association, 30th Convention, June, 1907.

Indefinite Candle-Power in Municipal Contracts, by E. Leavenworth Elliott.

Indefinite Obligations in Municipal Contracts, by Henry Floy.

Efficiency of Various Methods of Illumination, by E. A. Norman.

The Frequencies of Flicker at which Variations in Illumination Vanish, by A. E. Kennelly and S. E. Whiting.

The Effect of Frosting Incandescent Lamps, by Edward P. Hyde and F. E. Cady.

Electric Lighting in Germany, by G. Klingenberg.

Illuminating Engineering, as an Aid to Securing and Retaining Business, by C. F. Oehlmann.

Co-operative Lighting of Streets by Merchants, by H. J. Gille.

Methods of Securing Science Outlining Window Lighting, by Homer Honeywell.

Report of Committee to Consider Specifications for Street Lighting, by Dudley Farrand, Chairman.

New Developments in Arc Lamps and High Efficiency Electrodes, by G. M. Little.

North-Western Electric Light Association.

Outline Lighting, by Homer Honeywell, February 11, 1907.

Some Points on Illuminating Engineering for Small Central Stations, by J. R. Cravath, February 4, 1907.

National Commercial Gas Association, Second Annual Convention, January, 1908.

Gas Lighting in the Factory, by T. J. Litle, Jun.

Observations of the Methods of Handling the Lighting Industry Abroad, by R. M. Searle.

Practical Talk on Light and Illumination, by V. R. Lansingh.

Empire State Gas and Electric Association.

Buying and Selling Illumination, by E. L. Elliott, November 11, 1907.

New England Association of Gas Engineers.

Some Instances of School-Room Lighting, by N. W. Gifford, April 1, 1907.

American Institute of Electrical Engineers.

Light from Gaseous Conductors Within Glass Tubes, by D. MacFarlan Moore, April, 1907.

Pittsburgh Section, American Institute of Electrical Engineers.

Illumination, by Arthur J. Sweet.

National Bureau of Standards, Washington, D.C.

Geometrical Theory of Radiating Surfaces, with a Discussion of Light Tubes, by Edward P. Hyde: Reprint No. 51.

Talbot's Law as Applied to the Rotating Sectored Disc, by E. P. Hyde: Reprint No. 26.

Comparison of the Unit of Illuminating Intensity of the United States with those of Germany, England, and France, by Edward P. Hyde: Reprint No. 50.

On the Determination of the Mean Horizontal Intensity of Incandescent Lamps, by E. P. Hyde and F. E. Cady: Reprint No. 63.

Use of White Walls in a Photometric Laboratory, by F. E. Cady: Reprint No. 20.

An Efficiency Meter for Electrical Incandescent Lamps, by E. P. Hyde and H. Brooks: Reprint No. 30.

On the Theory of the Matthews and the Russell Leonard Photometers for the Measurement of Mean Spherical and Mean Hemispherical Intensities, by E. P. Hyde: Bulletin No. 2.

On the Determination of the Mean Horizontal Intensity of Incandescent Lamps by the Rotating Lamp Method, by E. P. Hyde and F. E. Cady: Reprint No. 3.

An Explanation of the Short Life of Frosted Lamps, by E. P. Hyde: Reprint No. 61.

A Comparative Study of Plain and Frosted Lamps, by E. P. Hyde and F. E. Cady: Reprint No. 72.

Review of the Technical Press.

Illumination.

There do not appear to have been many important papers dealing with illumination pure and simple during the past month. Several recent editorials in *The Electrical World*, however, deal with points of interest and importance, particularly those dealing with 'Architecture and Illumination' and 'Diffusing Light from High Candle-Power Sources.'

The whole question of the correct methods of lighting buildings of historic and æsthetic interest seems to have been prominently to the front in the United States, as is shown by the recent papers by Mr. Bassett Jones, Mr. E. L. Elliott, and others on the subject.

Cravath and Lansingh also contribute a short article to *The Electrical World* on the subject of residence lighting, in which they discuss the varieties of fixtures most suitable for living-rooms, dining-rooms, halls, kitchens, &c.

Recent numbers of the *Journal für Gasbeleuchtung* contain some description of the recent display of shop-lighting at the "Augur" exhibition in Berlin. It seems to be generally agreed that the methods of lighting of many of the firms exhibiting were not all that could be desired, attention being paid to the production of great brilliancy rather than to the illumination of the goods to the best advantage. It is remarked that there are several points which are specially important in shop-lighting. We wish first and foremost to light the goods so that every object in the window can be clearly and distinctly seen. This intention is often interfered with by the method of placing brilliant lights so that they are in the direct line of sight. We must also take care not to employ any kind of light which may have a damaging effect on the goods.... such, for instance, as causing coloured goods to fade rapidly. Also, when, as often occurs, lights are placed very near to the window panes, we must arrange so that the heat given out by them does not cause the deposition of moisture on the cold glass in winter, and so obscure the window. The article contains several illustrations of shops lighted by gas at the exhibition referred to.

McBeth (*Illum. Engineer*, N.Y., March) describes a form of calculator for the use of illuminating engineers. In ordinary work we usually employ the simple inverse square law, and wish to calculate the illumination at a given distance in terms of the intensity of the illuminating source and its distance away, or, conversely, to determine the candle-power necessary to produce a certain illumination. This can be accomplished by the calculator in question, and it is also possible to predict the ground-illumination at a given angle, yielded by a source of specified brilliancy and height from the ground.

Photometry.

C. O. Bond, in a recent paper before the Franklin Institute, discusses the various types of standards of light in use in the United States for gas-testing. These include the Hefner and Harcourt standards, and also the Elliott and Edgerton lamps, which are little known in this country. In the course of his paper he explains what the functions of such a working standard should be, and criticizes

the various lamps in use from this point of view.

One of the most interesting portions of the paper is that in which the author gives his experiences of the Harcourt lamp in the United States. He considers this lamp as the best gas standard, and quotes several instances of the exactitude with which such lamps have been reproduced from English standards. It is to be noted that the lamp in use in the United States differs in several details from that in use in this country, and this, in a standard, is undesirable, although the author states that the differences in design which occur are of trifling consequence, and do not materially affect the light yielded by the lamp.

Dow (*Gas World*, April 11th) discusses the effect of colour-blindness on the flicker-photometer. It has been suggested that such photometers are unaffected by any peculiarity in vision of this nature. The author points out that many different types of colour-blindness exist, and that adequate evidence does not seem to exist to induce any one to maintain this opinion with conviction. He himself has obtained results in accordance with those of Dr. Brodhun, who found that, in certain cases, colour-blind observers do obtain abnormal readings. Similar conclusions have been reached by Rood, Tufts, and others. In any case it is pointed out that such a property must be a very doubtful advantage in a photometer. Certain red-blind people, for instance, are defective both in colour and light sensation. Red objects appear dark in hue to them. Therefore, if such a person obtained normal results with a flicker instrument we should be disposed to fear that the flicker instrument in question did not really measure *brightness*.

Dr. Steinmetz has recently contributed a suggestion for a primary standard of light to the American Institution of Electrical Engineers. He points out that the comparatively small variations in the nature of what is called "white light" as exemplified by the various standards of light now in use does, to some extent, constitute a source of uncertainty. He appears to suggest the production of a variety of white light composed of light and the primary colours of certain specified wave-lengths in certain definite proportions. Some such lines occur in the mercury lamp. In the ordinary mercury amp there are three light lines in the green, blue, and yellow respectively. In order to obtain the red constituent it is necessary to employ a high-temperature such as is utilized in the quartz lamp of Heraeus; in the spectrum of this lamp distinct red lines occur.

Several recently published articles deal with graphical methods of obtaining mean spherical candle-power.

A. E. Kenelly (*Elec. World*, March 28th) describes a new method involving the measurement of the length of a line in place of an area as has hitherto been usual. The method only requires the use of a proctractor and a pair of compasses, and, it is claimed, is much simpler than the ordinary Rousseau diagram construction, but equally accurate. Kilmer and McBeth (*Illuminating Engineer*, N.Y., March) describe modifications of the ordinary methods. Kilmer employed squared paper and a cosine-scale in order to simplify the graphical construction. McBeth, working backwards from Kilmer's method, merely superimposes a transparent semicircular scale, on which polar co-ordinates at certain intervals are ruled, over the polar diagram of distribution of light of the source. We can then read off the values of candle-power corresponding to these ordinates and takes the mean.

Electric Lighting.

An important recent paper by H. W. Handcock and A. H. Dykes deals with the influence of the metallic filament lamp on existing methods of charging for electricity. The authors recognize the importance of the influence of these lamps, which may be soon available for high pressure and of small candle-power, on the industry. After reviewing the existing methods of charging they advocate the adoption of a system involving a fixed annual charge based upon the "contract-demand" of the consumer *plus* a charge per energy consumed. They are also impressed with the inequality of the prevailing system of allowing low rates of supply for heating and power which may, notwithstanding, be used at peak times. Nevertheless they suggest that the heating and cooking business should be welcomed on the ground that such business may enable companies to tide over the loss of revenue following the universal adoption of the metallic lamps. The introduction of the mantle, they point out, in spite of raising the general standard of candle-power, caused a marked decrease in the amount of gas sold for the time being; under these circumstances, the gas companies had found the extension of gas for heating and cooking a useful asset, and electricity might have a similar experience.

A recent article in *The Electrical Review* (April 10th, 'The "Metallic" in Use') deprecated the present careless methods of using metallic filaments commonly in use. These lamps were sold to many small consumers and contractors without their drawbacks as well as their advantages being clearly explained to them. The new lamps would prove a blessing in the industry only if care was taken to ensure their being used only when really advantageous. The technical press of current date also contains a number of editorials and articles dealing with the recent paper by Messrs. Handcock and Dykes, and the discussion thereon. In this connexion mention may be made of an amusing contribution, entitled 'Reason and Wright' (*Elec. Review*, April 17th), in which some possible incongruities arising from existing systems of charging are displayed.

There have also been a number of contributions bearing on the recent developments of electric lamps, some of them exceptionally complete and valuable, but too lengthy to be more than mentioned here. In a recent lecture Dr. Clayton Sharp (*Elec. World*, April 14th) dealt with 'The Tungsten Lamp,' and described the chief modern methods of manufacturing these lamps.

Recent numbers of the *Zeitschrift für Beleuchtungswesen* contain an exhaustive and valuable summary of processes of manufacture of metallic filament lamps in various countries, including full reference to the existing patents on the subject. The tungsten lamps have been fully dealt with, and the recent instalments of the series touch upon the application of thorium, yttrium, and other elements to glow-lamp manufacture. Mention is made of a recent patent of Lux, having for its object detection of inferior filaments. The graphitizing processes, rendering carbon filaments more homogeneous, are also described. Howell was the first to produce carbon filament lamps by this method, which would burn for 500 hours at an inefficiency of only 2·2 watts per candle-power. It is stated, however, that improved methods enable lamps burning satisfactorily for the same period at 1 to 1·5 watts per candle-power are now becoming practicable. The Parker and Clarke "Helion" lamp, in which a carbon filament is partially replaced by silicon, is also dealt with.

A somewhat similar series of articles, but on different lines, has recently been contributed by Duschnitz (*Elek. Anz.*, April 12th, 16th, and 19th). He deals with the recent developments in methods of leading in conductors to which the filaments of a lamp are attached, and the processes by which the required junction is accomplished. Finally, mention must be made of a summary (*Elek. u. Masch.*, April 12th) on the subject of recent patents applying to the mechanisms and structural details of arc-lamps.

Gas, Oil, and Acetylene Lighting.

One important recent contribution on this subject is that of Drs. Bunte, Mayer, and Teichel (*J. f. G.*, March 28th, and April 4th), on the processes of combustion occurring in the inverted incandescent mantle. In the first section of the article they enter into the theory of the inverted burner and the mantle generally, with special reference to high pressure lamps of the Lucas and Pintsch type. Subsequently they describe some interesting original experiments on the subject, chiefly bearing on the proportions of air and gas to be admitted. This portion of the paper is accompanied by photographs illustrating the modification in the shape of the flame with different mixtures, and also a curve and various tables illustrating the variation in intensity of light emitted from a lamp with different values of the gas-consumption, the relative proportions of gas and air being kept constant.

Equally interesting are the experiments of Prof. Wedding on the pressure of gas in burners, which are summarized in *The Journal of Gas-Lighting* (April 14th). Dr. Wedding traces the alterations in gas-pressure up to the nipple of the burner, where it is reduced to about 1·10 in passing through the fine orifice. With so low a pressure one need not wonder at the tendency to fire back, and it is important to keep what pressure remains as high as possible. Dr. Wedding prefers the drilling of a single in preference to several small ones; this single hole must, however, be smooth and well-drilled. He also refers to the benefit accruing from the preheating of gas before passing through the nipple, on which such divergent opinions have been expressed.

T. J. Little contributes to *The Illuminating Engineer* of New York a review of progress in inverted gas-lighting during the year 1907. Needless to say he considers the inverted mantle a great advance, and states that it has enabled gas to be profitably utilized, in many cases in which its use would otherwise have been out of the question. He refers to the efforts of gas companies in the United States to instruct the consumer

as to the best methods of using gas, both by means of organized meetings, and by distribution of educational pamphlets. Inverted mantles have found an extensive use in railway-carriage lighting. In shops they are now often supplied with flexible metallic tubes attached to overhead brackets. Self-lighting and distance-lighting devices are also making headway.

Mention must also be made of the series of contributions to the *Zeitschrift für Beleuchtungswesen* dealing with the most recent developments in inverted burners. Like the corresponding articles on the subject of glow-lamp manufacture, these contributions contain a full *resumé* of the existing patents, and should be of considerable value to those interested in the technicalities of the subject.

A recent number of *The Electrical Review* of New York contains a reference to a new method of producing gas from waste products. It is stated that 15,000 cubic feet of gas can be produced from one ton of refuse by sprinkling with an alkali chemical solution, and subsequently distilling at a temperature of 1,200 degrees F. The illuminating power is stated to be twice that of the ordinary grade of coal gas, and we are told that the gas "contains for power purposes 800 heat units."

Lastly, we may refer to the use of acetylene in connexion with inverted mantles for train-lighting on the French Northern Railway, which is described in the most recent number of *Acetylene*. Now that strong mantles, capable of resisting the wear and tear of railway traffic, are available, and the initial difficulties accompanying the application of acetylene gas to the incandescent mantle are to a large extent overcome, the simple storage of soluble acetylene is finding useful application. On these trains each coach contains 4 main burners yielding 25 candle-power, and burning 0·25 to 0·28 cubic feet per hour, and 2 additional smaller ones placed in the lavatories. A single charge of gas will supply the 8 burners in the carriage for nine go and return journeys, lasting about 5½ hours each.

Miscellaneous.

Electrolytically formed metallic mirrors have recently been found very effective for this purpose, but a recently-developed system, not based upon the electrolytic process alone, due to Mr. Cowper Coles, is said to lead to exceptionally good results. Alternate bands of golden and white reflecting surface are produced, and, it is claimed, that the resulting surface, enables a beam of exceptional intensity and penetrating power to be obtained. It is also asserted that the surface is unusually durable, withstanding concussion remarkably well, and being only locally affected by the impact of bullets.

The recent lecture by Professor Burch on Colour Vision is referred to elsewhere in this number.

List of References:—

ILLUMINATION.

Cravath and Lansingh. Economical and Efficient Plans for Lighting Small Houses (*Elec. World*, April 4, 1908).
Editorials. Architecture and Illumination (*Elec. World*, March 26).
Diffusing Light from High Candle-power sources (*Elec. World*, April 4, 1908).
McBeth, N. A Calculator for the use of Illuminating Engineers (*Illuminating Engineer*, N.Y. March).
The Lighting of a Shoe Store (*Illuminating Engineer*, N.Y., March).
Uber Schaufensterbeleuchtung (J. f. G., March 21 and April 11).

PHOTOMETRY.

Bond, C. A. Working Standards of Light and their use in the Photometry of Gas (*Jour. of the Franklin Institute*, March).
Dow, J. S. Colour-Blindness and the Flicker Photometer (G. W. April 11, 1908).
Kenelly, J. S. A new method of Determining the Mean Spherical Intensity of a lamp by the length of a straight line, the curve of meridional intensity being given (*Elec. World*, March 28).
Kilmer, A. A convenient method of drawing the Rousseau dingram (*Illum. Engineer*, N.Y., March).
McBeth, N. A method of determining Mean Sperical C.P., without the aid of the Rousseau diagram (*Illum. Engineer*, March.)
Steinmetz, C. P. A Primary Standard of Light (*Trans. Am. Inst. of E. E.*, March).

ELECTRIC LIGHTING.

Duschnitz, Bert. Die Bestrebungen zur Herstellung von Glühlampen-Elektroden aus unedlen Metallen oder deren Legierung (*Elek. Anz.*, April, 12, 13, 16).

Handcock, H. W., and Dykes, A. H. Electric Supply Prospects and Charges as affected by metallic filament lamps (Paper read before the Institution of Electrical Engineers, April 8, 1908. See also comment on the same in current numbers of Electrical Press in England).

Neumann, L. Uber die Konstruktion der Glühlampenfassungen und Glühlampensockel (*Elektrot. u. Masch.*, March 29).

Sharp, Dr. Clayton. The Tungsten Lamp (*Elek. World*, April 14).
The "Metallic" in use (*Elec. Review*, April 10).
Transformers for metallic filament lamps (*Elec. Engineer*, April 10)
Fortschritte auf dem Gebiete der Elektrotechnik und des Maschinenbaues Elektrische Beleuchtung, *Bogenlampen* (*Elec. u. Masch.*, April 12).
Fortschritte in der Glühlampenindustrie (*Zeit. f. Bel.*, March 30, April 10 & 20).
Reason and Wright (*Elec. Review*, April 17).

GAS LIGHTING, OIL LIGHTING, ACETYLENE, &c.,

Bunte, H., Mayer, M., and Teichel, E., Studien über Verbrennungsvorgänge bei Gasglühlichtlampen (J. f. G. March 28 and April 4).

Humphreys, N. H. The Gas of the Future (G. W., April 18).

Little, T. G. Progress of Inverted Gas Lighting during 1907 (*Illum. Engineer*, N.Y., March).

Smith. A. G. Public Lighting in Liverpool (Annual Report, G. W., J. G. L., March 31).

Wedding, W. Pressure in Inverted Burners (J. G. L., April 14).

Winkler, E. Vorrichtung zum anzünden mehrflammiger Gasglühlichtlampen (*Zeit f. Bel.*, March 20).
Neue Invertbrenner (*Zeit. f. Bel.*, March 20 and 30, April 10 and 20, continued).
Incandescent Acetylene for Train-Lighting (*Acetylene*, April).
Lampe à incandescence pour le pétrole lourd (*Jour. du Pétrole*, March 1).
Producing Illuminating Gas from Waste Products (*Elec. Review*, N.Y., March 28).

MISCELLANEOUS.

Burch, Professor G. J. Colour Vision (Lecture delivered before the Optical Society, April 1).

Jones, Bassett. A Plea for a Liberal Education for Engineers (*Elec. Review*, N.Y., April 11).
The Relation between the Conductivity and Illumination of Selenium (*Elec. Engineering*, April 3).
A New Metallic Mirror for Searchlights (*Elec. Engineering*, April 9).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
Elektrot. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
Z. f. Bel.—*Zeitschrift für Beleuchtungswesen.*

Acetylene Lamps on the Battlefield.

It is stated that the German War Office have been experimenting with acetylene lamps for use in war. For signalling purposes some such source of light, at once powerful and portable, is needed. A further case where these same qualities are very essential is in connexion with the army medical department, who are frequently in need of an easily movable strong source of light at short notice, for instance, when improvising shelters and conducting operations, or searching for the wounded.

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

5,719. Swing out lamp carriers. March 14. T. L. Scott, 51, Broomfield Avenue, Palmers Green, London.
5,829. Arc lamps. March 16. A. D. Jones, Hartham Works, Hartham Road, Holloway, London.
5,905. Lamp shade holders. March 17. J. H. Naylor and F. W. Cotton, Penny Bank Chambers, Halifax.
5,996. Brackets for supporting electric light globes. March 18. J. Pinson and P. H. Bibby, 5, Corporation Street, Birmingham.
6,059. Suspension devices for lamps. March 18. R. Baron, 111, Hatton Garden, London.
6,229. Arc lamps for theatrical stages, &c. (C.S.). March 20. T. J. Digby, 37, Essex Street, Strand. London.
6,407. Absorbing vibration in filament lamps. March 23. P. Druseidt, 20, High Holborn, London.
6,409. Incandescent filament lamps (C.S.). March 23. C. Pauli, 20, High Holborn, London. (Addition to 27,541/07.)
6,421. Arc lamps. March 23. Crompton & Co., Ltd., and C. Crompton, Arc Works, Chelmsford.
6,687. Incandescent lamps. March 25. The British Thomson-Houston Co., Ltd., and H. H. Needham, 83, Cannon Street, London.
6,751. Arc lamps. March 26. A. Holman, 44, West George Street, Glasgow.
6,974. Lamp holders. March 30. W. Fennell and W. P. Perry, 68, Dudley Road, Tipton, Staffs.
7,077. Arc lamps. March 31. H. Bevis and A. E. Angold, 3, Brown Street, Market Street, Manchester. (D.A. April 5, 1907.)
7,328. Arc lamps (C.S.). April 2. (I.C. Aug. 2, 1907, Germany.) Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
7,593. Water-tight lamp-holders. April 6. E. G. Byng and C. E. Gunner, 71, Queen Victoria Street, London.
7,674. Attaching shades and reflectors to incandescent lamps. April 7. C. W. Dawson, 30, Park Row, Leeds.
7,822. Electric lamps and their circuits. April 8. H. W. Handcock, A. H. Dykes, C. H. Stearn, and C. F. Topham, 47, Lincoln's Inn Fields, London.

II.—GAS LIGHTING.

5,732. Inverted incandescent lamps. March 14. J. Milne, Milton House Works, Edinburgh.
5,793. Lighting and extinguishing by varying pressure in mains. March 16. J. Rosie and J. McKelvie, 37, West Nile Street, Glasgow.
5,833. Inverted incandescent burners. March 16. E. J. Shaw, 60, Queen Victoria Street, London.
5,848. Incandescent burners. March 16. C. W. Harrison, 7, Southampton Buildings, London.
6,026. Incandescent mantles (C.S.). March 18. E. Ross, 56, Myddelton Square, London.
6,109. Controlling device for gas lights. March 19. J. M. Tourtel, 33, Cannon Street, London.
6,306. Incandescent lamps. March 21. R. O. Tweedie, 65, Chancery Lane, London.
6,365. Gas-light pendants (C.S.). March 21. S. Chandler and J. Chandler, Birkbeck Bank Chambers, Southampton Buildings, London.
6,468. Gas mantles (C.S.). March 23. (I.C. Aug. 10, 1907. U.S.A.) P. R. Finch, 31, Bedford Street, Strand, London.
7,157. Incandescent lamps. April 1. J. W. Bowley, 5, Corporation Street, Birmingham.
7,161. Gas mantles. April 1. A. A. Wade, 253, Hyde Park Road, Leeds, Yorks.
7,220. Inverted incandescent burners. April 1. J. Webber, 18, Southampton Buildings, London.
7,221. Fittings of inverted incandescent burners. April 1. J. Webber, 18, Southampton Buildings, London.
7,309. Controlling gas supply to lamps at a distance (C.S.). April 2. (I.C. July 23, 1907, Germany.) G. Himmel, 18, Southampton Buildings, London.
7,318. Controlling gas supply to lamps at a distance (C.S.). April 2. (I.C. Feb. 3, 1908, Germany.) G. Himmel, 18, Southampton Buildings, London. (Addition to 7,309/08.)
7,329. Intermittent gas lights for advertising, &c. April 2. A. T. Gilbert, 53, Chancery Lane, London.
7,461. Incandescent lighting. April 4. W. A. Handcock, 39, The Avenue, Beckenham, Kent.
7,541. Gas lamps. April 6. J. Keith and G. Keith, 65, Chancery Lane, London.
7,548. Gas lamps and burners. April 6. G. Helps, Izons Croft, Ansley, Atherstone.
7,791. Fittings for inverted incandescent burners and lamps. April 8. A. E. Podmore and J. Thomas, 256, Croxted Road, Herne Hill, London.
7,867. Anti-vibration attachment for incandescent burners. April 9. A. E. Baxter, 52, Monk Road, Bishopston, Bristol.

III.—MISCELLANEOUS.

5,708. Carrying shades of electric and gas lamps adjustably. March 14. E. A. Showell and E. H. Harris, Prudential Buildings, Corporation Street, Birmingham.
6,115. Lamps or lanterns. March 19. J. Hofmann, A. Koester, and F. Kumpernass, 111, Hatton Garden, London.

6,219. Means for illuminating. March 20. H. C. Dickson, 24, Southampton Buildings, London.
6,605. Holding gas or electric globes or shades in their galleries. March 25. A. Morrison, 13, Randolph Place, Edinburgh.
6,701. Increasing lighting power and durability of candles. March 26. T. S. Kendrick, 26, Upper Cox Street, Birmingham.
6,840. Solid wax lamps. March 27. E. Chalmers, 77, Colmore Row, Birmingham.
6,971. Photometer. March 30. W. Fennell and W. P. Perry, 68, Dudley Road, Tipton, Staffs.
6,997. Shade holder. March 30. R. Moore, 6, Kirkmanshulme Lane, Manchester.
7,240. Intensifying and diffusing illuminants. April 2. H. Sparks, 41, Mount Pleasant Road, Hastings, Sussex.
7,251. Acetylene generators and burners (high candle-power). April 2. W. Mills, 3, Brown Street, Market Street, Manchester. (Addition to 4,555/07.)
7,707. Lamps for illuminating, &c. April 7. G. Epstein, 54, Willow Road, Hampstead.
7,740. Globe galleries for gas burners, electric lamps, &c. April 7. S. Mundler, 4, South Street, Finsbury, London.
7,840. Lighting attachments for gas and acetylene burners (C.S.). April 8. (I.C. Aug. 10, 1907, U.S.A.). C. J. Larkin, 72, Cannon Street, London.
8,010. Acetylene burners (C.S.). April 10. D. J. Van Praag, 18, Southampton Buildings, London.
8,104. Filaments for illuminating and heating (C.S.). April 11. G. Michaud and E. Delasson, 7, Southampton Buildings, London. (Addition to 4,461/08.)

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

1,373. Lighting of railway and other vehicles. Jan. 18, 1907. Accepted March 25, 1908. C. A. Park and C. L. Mason, 77, Chancery Lane, London.
6,409. Lighting of railway and other vehicles. March 16, 1907. Accepted March 18, 1908. Sir W. G. Armstrong, Whitworth & Co., Ltd., and J. Honner, 24, Southampton Buildings, London.
6,893. Arc lamps. March 22, 1907. Accepted March 25, 1908. W. J. Davy, 40, Chancery Lane, London.
7,642. Filaments for incandescent lamps (C.S.). March 30, 1907. Accepted April 8, 1908. H. H. Lake, 7, Southampton Buildings, London. (From Parker Clark Electric Co., U.S.A.)
7,926. Arc lamps. April 4, 1907. Accepted April 1, 1908. H. S. Hatfield and F. M. Lewis, 18, Palmeira Square, Hove, Sussex.
7,941. Arc lamps. April 5, 1907. Accepted April 15, 1908. H. Bevis and A. E. Angold, Peel Works, Adelphi, Salford.
7,941A. Arc lamps. Oct. 21, 1907. H. Bevis and A. E. Angold, 3, Brown Street, Market Street, Manchester. (D.A. April 5, 1907.)
8,151. Fixing lamp shades or reflectors adjustably. April 8, 1907. Accepted March 25, 1908. J. Rawlings and R. T. Smith, 34, High Holborn, London.
8,388. Systems of lighting by arc lamps. April 11, 1907. Accepted April 1, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
8,563. Metallic illuminating bodies for incandescent lamps (C.S.). I.C. Aug. 30, 1906, Germany. Accepted April 15, 1908. Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 55, Chancery Lane, London.
8,641. Joints between lamp filaments and leads. April 13, 1907. Accepted April 15, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
10,071. Supports for filaments of incandescent lamps. April 30, 1907. Accepted April 8, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
10,931. Incandescent lamp bulbs (C.S.). May 10, 1907. Accepted April 1, 1908. D. F. Campbell, Fairfield Building, Vancouver, British Columbia.
16,383. Electric light fittings. July 17, 1907. Accepted April 15, 1908. H. M. Appleyard and E. Quiggin, 15, Water Street, Liverpool.
17,655. Arc lamps (C.S.). Aug. 2, 1907. Accepted April 15, 1908. W. G. Heys, 51, Deansgate Arcade, Manchester. (From The Scott Electrical Co., U.S.A.)
17,781. Arc lamps. Aug. 3, 1907. Accepted April 8, 1908. A. D. Jones, 18, Southampton Buildings, London.
17,972. Incandescent lamps with filaments made from a plastic mass (C.S.). I.C. Aug. 28, 1906, Germany. Accepted April 8, 1908. Siemens and Halske Akt.-Ges., Birkbeck Bank Chambers, London.
23,098. Incandescent lamps (C.S.). I.C. Nov. 5, 1906, Germany. Accepted March 18, 1908. Schott and Gen., Jena, Germany.
23,225. Arc lamps (C.S.). I.C. Sept. 6, 1907, Germany. Accepted March 18, 1908. D. Timar and K. von Dreger, 7, Southampton Buildings, London.
2,676. Holders for incandescent lamps (C.S.). Feb. 6, 1908. Accepted April 15, 1908. A. Loebl and British Ever Ready Electrical Co., Ltd., 111, Hatton Garden, London.
5,783. Incandescent lamps (C.S.). March 14, 1908. I.C. March 16, 1907, U.S.A. J. W. Howell, 83, Cannon Street, London.
6,245. Metal filament lamps (C.S.). March 20, 1908. I.C. March 27, 1907, Germany. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Buildings, Norfolk Street, Strand.

II.—GAS LIGHTING.

6,828. Incandescent mantles (C.S.). I.C. Jan. 28, 1906, Germany. Accepted April 1, 1908. G. Buhlmann, 111, Hatton Garden, London.

7,049. Inverted incandescent lamps. March 23, 1907. Accepted March 25, 1908. O. Imray, Birkbeck Bank Chambers, London. (From J. Pintsch, Germany.)

7,197. Lighting and extinguishing by varying pressure in mains. March 26, 1907. Accepted April 1, 1908. J. M. Tourtel and W. R. Mealing, 57, Chiswell Street, London.

7,540. Fabric for gas mantles (C.S.). March 28, 1907. Accepted April 1, 1908. G. J. Seckel, 40 Chancery Lane, London.

8,371. Self-lighting incandescent burners. April 10, 1907. Accepted April 15, 1908. W. C. Edwards, 325, Vauxhall Bridge Road, London.

8,535. Burners for flare lights. April 12, 1907. Accepted April 15, 1908. C. C. Wakefield, 111 Hatton Garden, London.

11,768. Incandescent lamps with horizontal burners. May 21, 1907. Accepted April 15, 1908. J. Hudler, 100, Wellington Street, Glasgow.

15,047. Lighting and extinguishing from a distance (C.S.). I.C. Aug. 18, 1906, Sweden. Accepted April 1, 1908. Aktiebolaget Gas-Accumulator, 46, Lincoln's Inn Fields, London.

22,821. Inverted incandescent burners (C.S.). I.C. May 13, 1907, Germany. Accepted March 25, 1908. (Firm of Ehrich and Graetz, 1, Broad Street Buildings, Liverpool Street, London.

793. Inverted incandescent burners (C.S.). Jan. 13, 1908. Accepted April 15, 1908. M. Graetz, 18, Southampton Buildings, London.

2,285. Inverted incandescent burners (C.S.). Feb. 1, 1908. Accepted April 15, 1908. J. W. Bray, Sunbridge Chambers, Bradford, Yorks.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

7,497. Incandescent petroleum lamps. March 28, 1907. Accepted March 25, 1908. A. Meissner and J. Danischevski, 6, Lord Street, Liverpool.

13,476. Vapour-burning lamps (C.S.). Jan. 11, 1907. Accepted April 8, 1908. M. W. Pitner, 615 F. St., N.W., Washington, D.C., U.S.A.

23,796. Use of compounds of ammonia and higher fatty acids for illuminating purposes (C.S.). I.C. Nov. 13, 1906. Accepted April 8, 1908. F. Engelhorn, 47, Lincoln's Inn Fields, London.

330. Lamp shades (C.S.). I.C. Jan. 11, 1907, U.S.A. Accepted April 8, 1908. W. O. Holt and R. L. Foster, 173, Fleet Street, London.

5,030. Illumination and heating by vapour burners (C.S.). March 5, 1908. I.C. March 6, 1907, France.

6,775. Non-combustible lamp wick (C.S.). March 26, 1907. I.C. March 28, 1907, Germany. B. Monasch, 27, Chancery Lane, London.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.—Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

TRADE NOTES.

A New Arc Lamp Coupling.

We have received from Messrs. The Union Electric Co., Ltd., an account of a new form of strain release and arc lamp coupling. The distinctive feature claimed for this arrangement is that no question can arise as to whether or no the lamp has been hoisted to exactly the correct position; it is merely necessary to hoist up to a certain stop.

Metallic Filament Lamps of British Manufacture.

The "Metallite" lamp is described in a leaflet recently issued by the Bryant Trading Syndicate. From the results of some tests on these lamps, we are given to understand that a life of 1,000 hours, at 1 watt per c.p., with practically no diminution in initial candle-power and efficiency, was realised. The lamps are also listed for pressures up to 250 volts.

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The
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EDITORIAL.

THE message of Dr. Louis Bell, the president of the Illuminating Engineering Society in the United States, which we print in our present number, should be read with interest and encouragement by all those in this country who have the improvement of existing methods of illumination at heart. We do think that all, reading Dr. Bell's remarks, will agree with us that the record of the Illuminating Engineering Society in America, which has only been in existence for about two and a half years, is an exceptionally fine one.

It is not only to the exceedingly rapid growth of the society to which we would draw attention. It has already achieved solid, useful work which no other society was prepared to undertake. It has been the means of bringing together all the many trades and professions—architects, medical men, electrical and gas engineers, fixture-makers, &c.—who are interested in the subject of illumination, in order to work for a common aim. It has enabled the gas and electrical societies to come together and work in harmony, and one important result has already been brought about owing to such co-operation—namely, a temporary agreement upon a single accepted unit of light and the recognition of a single authority, the Bureau of Standards, as arbitrator in cases of dispute.

We must also express our admiration of the organized efforts of the society to promote the improvement of illumination in schools and public buildings. This is a subject to which we have already repeatedly called attention. The case of schools, in particular, demands the attention both of lighting engineers and medical authorities, and we have recently strongly advocated the systematic inspection not only of the eyesight of school-children, but also of the defective conditions of illumination which are admittedly partially responsible for the defects in eyesight, &c., known to exist. As an illustration of the evident desire on the part of engineers in the United States to keep in touch with the very latest

developments, we may mention that Dr. Bell, among others, is paying a special visit to the chief European cities with the express object of studying the different methods of street-lighting.

Illumination from the Standpoint of Municipal Authorities.

In our present number we give an account of the recent lectures and demonstrations of the measurement of illumination at the Municipal Exhibition which was opened on the 1st of last month. The object of these lectures and demonstrations was to call attention to the need for consideration of matters in illumination on the part of the municipal authorities responsible for the lighting of our streets and public buildings.

Naturally our suggestions, while attracting some attention, have not escaped criticism, and one of our contemporaries comments upon the matter in the editorial remarks of two recent numbers. As far as we understand, it does not seem to be disputed that the objects that we have in view are good, or that illumination really does deserve very much greater consideration from the hands of authorities than at present. The only difficulty appears to consist in the problem of realizing the ideal conditions. In this connexion our contemporary remarks: "Municipal authorities are responsible for a great deal of artificial lighting.....But there are few among the thousands of municipal councillors in this country who understand anything of the principles of illumination; and personal and municipal interests and official influences play a greater part now, and ever will do, than any scientific principles in determining the form of illumination to be applied in any place."

We of course agree that the principles of illumination are not as generally appreciated as we desire them to be; otherwise we would not be calling attention to the matter. It is unfortunately true that comparatively few of our municipal councillors realize the importance of good illumination, and the main object of the demonstrations described in this number was to draw public attention to the subject.

But we must also enter a protest against the assumption that because the present condition of things is unsatisfactory it is destined to remain so for ever. The mere fact of our having been invited to undertake the lectures and demonstrations referred to is in itself gratifying evidence that the importance of good illumination, from the municipal standpoint, is beginning to receive recognition; we only see in the present defective conditions an inducement to persevere in order that there may be improvement in the future.

No doubt, as our contemporary remarks, there are "walls of Jericho" to be overturned or pierced, and we are not so sanguine as to suppose that they will immediately succumb to the blast of our trumpet. We are aware that much patient work will be necessary in order to make any great progress. But 'THE ILLUMINATING ENGINEER,' aiming, as it does, at an impartial and international outlook, is at least unhampered by walls of its own making, and relies upon the assistance of many friends, in different camps, but all working for the same fundamental objects.

In the same way we cannot agree that because different people have different ideas as to what constitutes good illumination, therefore we should abandon our endeavour to come to some agreement on these questions of dispute. On the contrary, we only see in this fact a reason for gathering such people together in order that mutually conflicting views may be put forward and discussed.

If this is done we shall eventually come to understand what is essential in good illumination and what is not; if, on the other hand, we adopt a policy of *laisser faire*, naturally no progress will be made, and we shall merely

continue to hear vague and conflicting statements on matters that have never been properly investigated.

While laying stress on the value of actual measurement and specification of illumination, we, however, have no desire to see any rigid system of measurement rashly and suddenly adopted. The matter requires careful consideration. Then by all means let it be carefully considered. But as long as the problem is shirked and the existing difficulties, instead of being inquired into and met, are regarded as insuperable, the details of the scheme cannot materialize. It is for the very purpose of discussing problems of this nature that we desire to see an illuminating engineering society established in this country.

And we can only feel that an engineer who dismisses the illuminometer as unworthy of consideration shares the prevalent want of knowledge of what has already been done in developing such instruments. We cannot agree that the use of an illuminometer, in order to test the actual existing illumination, can be anything but beneficial to the central station engineer in his dealings with the consumer. For he would then have at his command an actual test to prove beyond dispute that the illumination under actual conditions is as high as it should be. As long as we continue to rely upon ocular demonstration instead of actual measurement, he is at the mercy of a fluctuating standard in the mind of the public as to what is required. But when it has been definitely agreed that the illumination is not to fall below a certain value, the engineer is empowered to determine for himself by actual measurement whether the complaints of the consumer are justified.

The General Interest in Illumination.

We have occasionally heard laments that but little progress in arousing interest in the subject of illumination has been made in this country since the movement was first brought into prominence about two years ago. Those of us who have been following the development of interest in the matter closely have certainly no ground for complaint. The only wonder is that such gratifying progress has actually been made. The change in the general outlook has been so gradual as to escape the notice of those who have not been in a position to trace the slow but sure course of events. Of course such changes take place slowly, but it is right that this should be so. One has only to compare the contents of the technical journals of to-day with that of those of only two or three years ago in order to realize the increase in the number of those anxious for information on the subject. At that time articles dealing with illumination were few and far between; to-day the task of keeping in touch with the constant stream of literature dealing with one or other aspect of illumination is no light one, as we have good reason to know.

We naturally feel that the starting of our own journal represents a very great step in the right direction. Moreover even the non-technical reader has become aware of the importance of the subject of illumination, as those responsible for the organization of public lectures or demonstrations relating to lighting will readily agree.

Recent Progress in Gas and Electric Lighting.

The recent papers by Messrs. Handcock and Dykes and Mr. Hirst dealing with the metallic lamp situation afford evidence of the general recognition of the importance of these recent developments both to the electrical industry and the general public. We ourselves cannot believe that the introduction of more efficient means of producing light if properly handled can ultimately be anything but beneficial both to the consumer and the lighting industry.

One of the most gratifying features of the discussion of the latest paper

mentioned was the emphatic condemnation of unshaded metallic filaments by several speakers and their realization of the fact, constantly urged in these columns, that the advent of the metallic filament lamp with its higher efficiency enables us to bear without flinching the relatively small loss in light caused by such adequate methods of screening the filament from the eye. Dr. Bell, indeed, paid a tribute to the growth of appreciation of this point in the United States when he declared that in that country none would now attempt to utilize metallic filament lamps without a suitable diffusing shade.

Those who were present at Mr. Hirst's paper could not fail to be impressed with the rapidity with which the situation has developed, but we question whether they could have fully realized the immense number of workers now engaged in the field and the great variety of metallic filament lamps which are either on the market now or likely to be shortly. It is wonderful to consider that in about two years we have seen the development of a metallic filament from a high C.P. low voltage scientific curiosity to a serviceable high voltage, and relatively low C.P. lamp claimed to be able to burn in any position.

Some of us, it is true, were aware of actual achievements of manufacturers in this direction very much earlier, but now they are actually on the market and available to all. Those who are in touch with yet more recent experimental developments can hardly doubt but that still more remarkable results will be achieved in the near future. In this connexion we may draw attention to the articles by Dr. Weber and Dr. Jacobsohn in 'THE ILLUMINATING ENGINEER,' in order to give some impression of the extent of the work that is being done and the immense number of important continental patents bearing on the subject.

When we bear in mind the number of processes which the metallic filament lamp must undergo before it arrives at its final state of perfection, and the great chemical and physical difficulties which they entail, one can only wonder at the ingenuity and scientific knowledge which have already achieved so much and are vanquishing, one by one, the existing obstacles. The contractor may well be dismayed at the ever-increasing variety of lamps at his disposal, and he is certainly in need of expert guidance to determine his choice.

Meantime those interested in gas-lighting have not been idle. The number of incandescent gas-lights available is increasing continually, and improvements both in mantles and in the direction of attaining higher pressures and the most perfect mixtures of gas and air, and utilizing this mixture to the best advantage, are constantly being made. The very complete description of the tests undertaken in connexion with the Scottish National Exhibition, which Mr. Herring has kindly sent us for inclusion in this number, contains a variety of information which will doubtless be found of considerable value by those who wish to form an estimate of the performances of different incandescent gas-lights under certain specified conditions. The article illustrates very clearly the constant efforts that are being made to improve incandescent gas-lighting and the large number of makes of lamps now available.

We make special comment upon the matter in order to illustrate the contention in the editorial of our last number, which those interested in electric lighting will do well to realize, that, while such great strides are being made in electric lamps, the development of gas-lighting is also proceeding rapidly.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter discusses the various ways in which examples of STREET-ILLUMINATION MAY BE COMPARED. He treats the consideration of the average or mean illumination over an area by geometrical methods, and taking a simple theoretical case, and avoiding any difficult mathematics, shows how this mean may be calculated.

Dr. Louis Bell, the president of the Illuminating Engineering Society, contributes A MESSAGE TO THE READERS OF 'THE ILLUMINATING ENGINEER.' He explains how the recognized need for a body of men, well acquainted with all aspects of illumination, has led to the development of the Illuminating Engineering Society in America, and how the society has already been the means of bringing together those interested in all these many aspects.

He also cites some important results which have arisen through this co-operation, such as the agreement on a common standard of light, the promotion of an organized inquiry into the conditions of illumination in schools and other public buildings.

Prof. E. W. Marchant contributes a discussion of some recent experiments carried out with the object of comparing the merits of FLAME AND OTHER ARCS FOR EXTERNAL ILLUMINATION. He points out the great difference in the shape of the polar curve of distribution of light in the case of arcs having inclined and vertical carbons respectively, and shows how the merits of each system depend upon the conditions under which the lamp is to be used. He also draws attention to the large amount of light frequently absorbed by the globes used in connexion with flame lamps, and refers to the question of the penetrating power of light of different colours in fogs.

Dr. C. V. Drysdale continues his treatment of LUMINOUS EFFICIENCY AND THE MECHANICAL EQUIVALENT OF LIGHT. In the present section he reviews the existing work that has been done on this subject and the various methods employed, and gives the results of a series of investigators on a large number of different illuminants, ranging from the candle to the vacuum tube.

Dr. F. Jacobsohn contributes a comprehensive review of the recent developments in the subject of METALLIC FILAMENT GLOW-LAMPS. In the previous article on the subject he dealt with the matter in a general manner, and he now enters into greater detail, describing the chief methods of preparing tungsten filaments and also the various suggestions relating to the practical utilization of other materials for glow-lamp manufacture. The article is accompanied by full references to the recent patent literature on the subject.

Mr. Haydn Harrison deals with the MEASUREMENT OF STREET ILLUMINATION. He sums up the various factors that enter into such problems, and discusses the chief difficulties arising in deciding upon a method of measurement. He also classifies the errors to which measurements by means of illuminometers are mainly due, and gives a number of hints for the benefit of those who use these instruments.

Dr. W. Biegon von Czudnochowski contributes a description of A NEW FORM OF ILLUMINATED SIGN recently exhibited at the "Augur" exhibition in Berlin. The essential feature of this sign consists in the mounting of the various mottoes or emblems to be illuminated on a dark surface, the sign itself consisting of some highly reflecting material.

Mr. W. R. Herring contributes an exhaustive report of the GAS LIGHTING AT THE RECENT SCOTTISH NATIONAL EXHIBITION. The results embrace a very large number of different type of lamps, full details being given of the

conditions under which the various lights are tested. Special interest attaches to the test on the new Keith high-pressure gas light, yielding 60 to 70 candle-power per cubic foot of gas.

Mr. Chas. W. Hastings continues his articles on the EDUCATION of those concerned with ARTIFICIAL ILLUMINATION. In the present case he dwells on the number of different spheres of knowledge with which the gas engineer dealing with lighting questions must make himself acquainted.

The **Special Section** in the present number is devoted to the lectures and demonstrations on the subject of ILLUMINATION AND LIGHT MEASUREMENT AT THE MUNICIPAL EXHIBITION, which took place from the 1st to the 12th of May. The two lectures of **Mr. Leon Gaster** and **Mr. J. S. Dow** dealt with 'EFFICIENT ILLUMINATION AND MUNICIPAL REQUIREMENTS,' and 'THE MEASUREMENT OF LIGHT AND ILLUMINATION' respectively.

Mr. Gaster dwelt upon the importance of illumination to those who are actually responsible for the lighting of our streets and public buildings. He also drew attention to the effect of light conditions on eyesight, pointing out the great importance of ensuring adequate conditions of illumination in the schools throughout the kingdom.

The subject of street illumination was also briefly touched upon, and the suggestion put forward that the different municipalities interested should combine together to equip a joint testing institution where impartial tests, by recognized authorities, could be properly carried out.

The lecture by Mr. Dow consists mainly of a popular review of recent progress in the measurement of illumination. It is pointed out how much more precise is the science of light measurement at the present day compared with that of a few years ago. A plea is put forward for greater co-operation between those interested in photometry, but representing different systems of lighting.

The section also contains a complete description of the various instruments exhibited, and there is also some account of the various lighting exhibits.

Among other articles reference may be made to that on a new method of SHOP LIGHTING BY GAS, according to which the lights are situated behind diffusing panels of frosted glass, placed above the goods contained in the window.

The paper by **Dr. Louis Bell** on the PHYSIOLOGICAL BASIS OF ILLUMINATION is concluded in the present number. This section of the paper deals mainly with colour phenomena, such as the Purkinje effect, the behaviour of the rods and cones on the retina, and the results of want of achromatism of the eye.

The recent paper by **Mr. Hugo Hirst,** before the Institution of Electrical Engineers, contains a résumé of recent progress in the manufacture of TUNGSTEN METALLIC LAMPS. The author sums up the historical development of the metallic lamps, and describes the chief processes by which tungsten lamps are now made. In the last part of the paper a series of practical cases are considered, and a number of useful tables given relating to the saving to be accomplished by the use of metallic filament lamps under various circumstances, the losses in small transformers, &c. There is also an abstract of the main points raised in the discussion following the recent paper by **Messrs. Handcock and Dykes.**

A paper by **C. A. Bond** gives an account of the various STANDARDS OF LIGHT USED FOR THE TESTING OF GAS in the United States; after reviewing the existing standards the author expresses himself as being in favour of the 10 c.-p. Harcourt lamp, which has been much utilized in America. In this connexion he gives several interesting examples of the accuracy with which such lamps are reproduced and tested.

At the end of the number are to be found the usual **review** of the existing TECHNICAL LITERATURE ON THE SUBJECT OF ILLUMINATION, and the **Patent List.**

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 363.)

Bases of Comparison of Cases of Illumination.—There is a tendency in many branches of knowledge to attempt to express a very complex quantity by a single figure of merit; but this is often done at the sacrifice of lucidity, and with the loss of anything that can be called description. The horse-power of a steam-engine carries no idea of its weight or the number of revolutions, if any, per minute; the tonnage of a ship tells nothing about its shape or suitability for blue water. The figure of merit of a galvanometer may seriously mislead one who is choosing an instrument, and the mean hemispherical candle-power of an arc lamp is almost as vague as any of the other examples.

Various suggestions have been made for a basis of comparison of different cases of illumination; for example, of two streets, one lighted by gas and the other by electric light. The eye is the ultimate judge. No amount of theorizing can establish any better criterion, and if any rules, formulæ, or curves can be found to express the degree and the distribution of illumination, those will be best which agree best with the opinion of a commonsense critic. Some writers have suggested that the minimum illumination is all that matters, and the rest may take care of itself. Others have argued that the mean illumination is the best measure. Others have proposed that the practical measure of the efficiency of lighting is given by the difference between the brightest and the dimmest parts of the illuminated area.

A curious unit, called a "candle-foot-yard," has been used. It is intended to express the average illumination over an area. A number of measurements were made along a street, from lamp to lamp; an illumination curve was plotted; and the "total effective illumination" was said to be the mean illumination as deduced from the average height of the curves, multiplied by the length of the street along which the measurements were taken. Though the comparison of a number of different cases reduced to this unit affords some useful comparison between the different lamps, and may justify comparisons of costs based on these measurements, a little reflection will show that such

a method cannot describe the illumination of the street. It is true only for an indefinitely narrow strip along the line of measurements, and if this is the line of the lamps, the true average is considerably lower than the value thus found.

It has been suggested that the term "luminous flux per unit area" ought to be used instead of "illumination" in certain mathematical considerations,* but in general, for the practical engineering point of view, the more the ideas of flux and 4π are suppressed the better. In considering the average illumination over an area, the idea of flux cannot be avoided; but it is not necessary to use difficult mathematics. The curve in Fig. 26 is the duplication of Fig. 9. It represents the illumination due to a lamp emitting light uniformly in all directions. All that goes above the horizon, that is, one half, is lost; the other half falls on the ground at a greater or less distance. The total flux of light emitted in all directions by a radiant point is 4π (see p. 182), and the useful flux emitted and received on an indefinitely extended horizontal plane is one-half of this, or 2π.†

The figure of revolution of the curve—in other words, the hill of which Fig. 26 is a section—has a solid volume of 2π. Its height over any point on the plane is a measure of the illumination at that point.

Consider it as a hill of sand on a floor of infinite extent. The layer of sand becomes thinner and thinner, theoretically never diminishing to nothing. As the hill theoretically extends over an infinite number of square feet, the average weight per square foot is infinitely small. In order to obtain any appreciable average, a limited area must be chosen. The problem is: a circle of a given radius being described about the axis of this hill, to determine the average height over that circle, or, in other words, the height of a cylinder having that circle as a base, and having a solid content equal to that part of the hill which is within the circle.

Imagine the source of light to be at the centre of a globe partly transparent and partly opaque. Let the transparent portion be just large enough to allow light to pass to illuminate the given circle, and let the opaque part cut off all the rest. Then the area of the transparent part of the globe is a measure of the solid angle, and this measures the flux or total light.



FIG. 26.

This solid angle may be expressed trigonometrically, and the calculations may be carried out by integral calculus; but though these are rapid they are not necessary. The matter may be treated more intelligibly for most people by Archimedes' theorem. Let A B P C D be half of a sphere of unit radius, and A E D F a circumscribing cylinder. Let O P be the axis common to the sphere and to the cylinder, and let G L B C K H be a plane perpendicular to the axis, cutting the sphere at B and C and cutting the cylinder at K and L. Archimedes found that the surface of the half sphere and of the cylinder are equal, and are 2π; that the spherical surface B P C is equal to the cylindrical surface L E K F, and

* E. P. Hyde on 'Geometrical Theory of Radiating Surfaces,' Bureau of Standards, America, *Bulletin* 3; also 'Science Abstracts' 1148, 1907.

† The equation of this curve is $y^2=\left(\frac{1}{1+x^2}\right)^3$, taking the foot of the lamp-post as the origin. It may be shown by integral calculus that the solid contents of this curve about its vertical axis is 2π. See Trotter on 'A Dioptric System of Uniform Distribution of Light,' *Proc.* Inst. Civil Engineers, 1883, vol. lxxviii. p. 335.

the spherical surface A B C D is equal to the cylindrical surface A L D K.

A quadrant of a sphere of unit radius being drawn (Fig. 28), let O A and O B be rays falling on the plane at the points A and B. Erect perpendiculars at D and E. The lengths A D and B E represent the flux falling within the cones swept out by O A and O B. They also are a measure of the solid angle.*

By this construction, a number of points such as D and E may be obtained, and thus the curve (Fig. 30) may be constructed. The vertical scale on the right gives the flux or solid contents. At an angle of incidence of 60 degrees, that is to say, a circle subtending 120 degrees, one quarter of the total flux of 4π is received, or one-half of that which is emitted in one hemisphere.

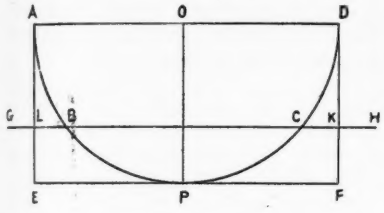


FIG. 27.

In the explanation of the illumination of inclined surfaces (p. 97) Fig. 6 represented a beam passing through a hole one foot square, and it was shown that as the screen was tilted, the illuminated area increased and the illumination decreased. In that elementary treatment it was desirable to keep the idea of flux out of sight, but we may now regard illumination as the flux divided by area. In the Geneva units the lux is equal to the lumens per square metre.

We can now deal with the problem, first arithmetically, and afterwards graphically. Taking a case from Table I., p. 185, let A B (Fig. 31) be unity, and the radius B C be 1·702. This is the case when the angle θ is 59 degrees 34 minutes (Tan. 59 degrees 34 minutes = 1·702). Cos θ is found in the table to be 0·507. Then $1-\cos\theta = 0{\cdot}493$, and $2\pi \times 0{\cdot}493 = 3{\cdot}1$. This is the solid content of the hill within the circle. The area of the circle is $\pi \times 1{\cdot}702^2 = 9{\cdot}11$. The height of the cylinder having a base 9·11 square units, and a solid content of 3·1, is $3{\cdot}1 \div 9{\cdot}1 = 0{\cdot}341$. The maximum illumination being 1, and the minimum being 0·13, the mean is 0·341. The mean height of the section in Fig. 31 is 0·507, which is a very different matter, being about 65 per cent. higher than the true mean. It may be observed that the mean height of all the ordinates of the cosine cubed curve up to any point is the cosine at that point.

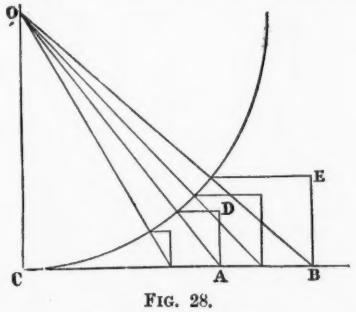


FIG. 28.

In Fig. 32 the same problem is solved graphically. Let A B be the height of the source of light, and be numerically equal to unity, and let B C be the radius of the circle. In A C cu off A D, making A D equal to A B. Drop the perpendicular D E, then D E is

* The trigonometrical treatment is as follows: Let O A be a ray falling on the sphere at A. Through A draw the perpendicular B A C. Then A C measures the solid angle, since it is equal to the height K F (Fig. 27) of the cylinder.

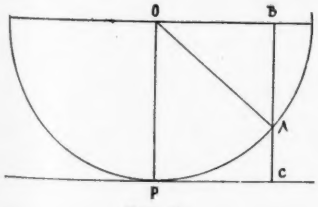


FIG. 29.

Let θ be the angle P O A, then the ratio B A to O P is cosine θ, O P being unity. Then A C is $1-\cos\theta$. The circumference of the cylinder being 2π, the surface L E K F (Fig. 27) is $2\pi(1-\cos\theta)$. This is the ordinary trigonometrical expression for a solid angle.

$1-\cos\theta$. Make B F in B A produced equal to B C; draw F G parallel to A C.

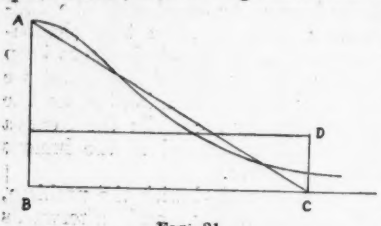


FIG. 31.

Then (A B being 1) 1 : B C :: F B : B G; therefore B G = B C^2. In B G cut off B H equal to twice D E. Then B H = 2 $(1-\cos\theta)$. Join G A, and through H draw H K parallel to G A. Then G A : 1 :: H K : K B. Therefore K B = 2 $(1-\cos\theta)$/B C. It will be seen that K B (Fig. 32) is equal to D C (Fig. 31).

Although this calculation of the mean illumination can be easily carried out by means of the tables and a slide rule, or, in the absence of tables, by the graphical construction, the simple case of a source of light of uniform candle-power in all directions, and of a circular area, is not one that is likely to occur in practice. It is introduced here to explain the theoretical principle of a mean illumination.

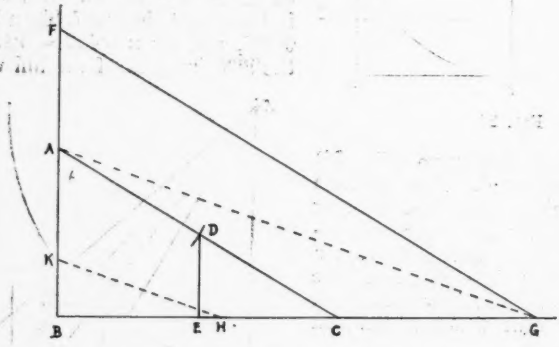


FIG. 32.

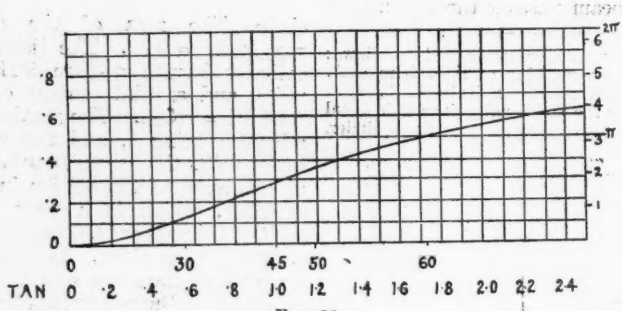


FIG. 30.

(To be continued.)

Message from Dr. Louis Bell of Boston.

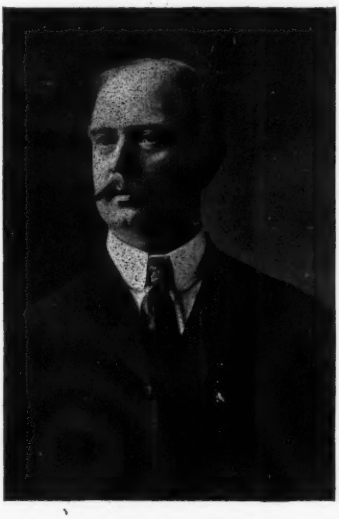
PRESIDENT OF THE ILLUMINATING ENGINEERING SOCIETY OF U.S. AMERICA.

To the Readers of 'The Illuminating Engineer.'

It may not be inappropriate to give some account of the growth of illuminating engineering in the United States.

The Illuminating Engineering Society was formed about three years ago, in response to a very definite feeling among those who were interested from various sides in artificial illumination. Though their interests are apparently diverse in many things, they are really the same in one thing—to wit, the proper utilization of the means of artificial lighting now at hand. There had come to be a very strong feeling that artificial lighting, through the advent of new illuminants, was verging on a fresh career of usefulness, and that it was high time to take advantage of the new means at hand to put illumination, as such, on a proper scientific basis. It is just as important, from the purely practical standpoint, to double the effectiveness of the illuminant sources actually at hand, as it is to invent a new incandescent lamp, or progressive lamp burner, of twice the efficiency of the old. The utilization, therefore, of illuminants as they are, in the most useful and efficient manner, is the primary object of illuminating engineering, as contradistinguished from electrical engineering, which deals with the means rather than the end, or gas engineering, which occupies a precisely similar position with respect to the great gas industry.

The Illuminating Engineering Society was therefore formed to further this eminently practical purpose of improving the art of artificial lighting, and of promoting such a mutual study of the technique and science of lighting as would lead to useful ends. The membership of the society, now about 1,000, has been, as might have been expected, drawn from no particular profession, but very many professions and branches of business. The membership includes many electrical engineers and gas engineers, managers of electrical supply stations and of gas stations, a considerable group of distinguished oculists, who are interested in improving the hygienic situation of present illumination, architects, teachers, contractors, and business men who have to deal with the difficulties of getting proper illumination, even when an adequate supply of illumination is at hand. It is this heterogeneous membership that best bears witness to the fact that illuminating engineering is not a branch of any one fashion, but deals rather with a new and extremely practical set of problems. The work of the society has been in large measure a campaign of education—self-education, as well as education of the public—and it has met with a gratifying degree of appreciation. As a convenient meeting ground of all lighting interests, the



Dr. LOUIS BELL,
President of the Illuminating Engineering Society in the United States.

society has been able to accomplish some very practical things in the way of bringing those very lighting interests to a common view-point.

One of the important steps taken has been the establishment of a modus vivendi whereby the gas and electrical industries have settled in a friendly way upon an identical working value for the standard candle: this will serve to avert many disputes. There had been an outstanding difference between the units customarily used in the electrical incandescent lamp industry, and those used by the gas engineers. Gas lighting in the United States has, in the past, depended, through statutory requirements, on the old British sperm candle and its alleged unit of light. As everybody now knows, this particular unit is both inconvenient and unreliable, yet, under existing conditions, it was continually being used by municipal gas inspectors, and was a source of perennial dispute between the supply companies and the municipalities, even when each body was trying in good faith to do its best to come to an agreement. A committee of the Illuminating Engineering Society secured the friendly co-operation of committees from the Institution of Gas Engineers and Am. Inst. of Electrical Engineers, and all three bodies, with no friction or difficulty, came to an amicable understanding, so that from now on they will be able to work with the common unit, and all disputes can be referred to the National Bureau of Standards with the certainty of a settlement on the practical basis of which all minds are agreed.

Another line of work in which the Society has been specially active is the promotion of good lighting in schools and public buildings. Considerable work in the way of investigation has been done by the various members working along various lines, and all directing proper attention to the hygiene of illumination, a subject much neglected, both in America and in this country, and one which has a peculiar importance on account of the enormous intrinsic brilliancy of the new illuminants, such as metal filament incandescent lamps and high pressure gas burners. These sources of light require very careful treatment in order to secure suitable illumination from them without subjecting the eyes to undue strain. A technical matter of this kind cannot be settled offhand by any electrical or gas engineer who chances to be confronted with the problem, requiring as it does, a close knowledge of the physiological aspects and intimate acquaintance with the technique of both gas and electric lighting.

The rise of such problems, and their importance from a purely practical standpoint, is sufficient reason for the existence of a body of illuminating engineers, who can well devote much of their time to the study of some intricate conditions which do not lie within the ordinary sphere of the electrical or gas engineer. As new illuminants appear, they bring with them new conditions, which must be followed up and studied, if these illuminants are to possess the usefulness which one may hope for them.

One can hardly say, of course, that illuminating engineering as a profession can take independent rank, in comparison, for example, with civil or electrical engineering. It makes no such pretence, but it is co-ordinate in importance with many branches of the engineering professions in which the development of new conditions has compelled specialization to a degree which a few years ago was totally unnecessary. In this sense illuminating engineering may properly claim full recognition in the engineering profession, and, let it be hoped, with the attention which has been drawn to it of late, will lead to a better understanding of the means available for artificial illumination, and more efficient utilization of the illuminants now at hand and rapidly appearing.

Mankind is becoming more and more a nocturnal creature. The modern city has to adjust itself to conditions where artificial lighting is predominant, and, consequently, the scientific use of artificial illumination must steadily assume greater and greater economic importance.

A Novel Method of Shoplighting by Gas.

In a recent number of the *American Gaslight Journal*, to the courtesy of whom we are indebted for the use of the blocks accompanying this article, appeared a description of a novel method of shoplighting employed by the Welsbach Company in one of the drapery stores of Philadelphia.

The window was boxed in, in the manner shown in the illustration, and a number of the wooden panels above the goods were removed and sheets of frosted glass substituted. As a rule, the side of the glass presented to the goods is the frosted portion. The sources of light used to light the window were then arranged at intervals behind this glass, as shown in Fig. 2. As a result a pleasing and uniform illumination is produced, the light being thrown down upon the goods without the possibility of very bright sources of light bewildering the eye of any one looking in at the window. In the case of the store shown in Fig. 1, the wooden panels have been entirely replaced by diffusing glass, with the object of producing well-distributed and uniform illumination. It is, however, also possible only to utilize a few individual panels with the object of producing bright local illumination.

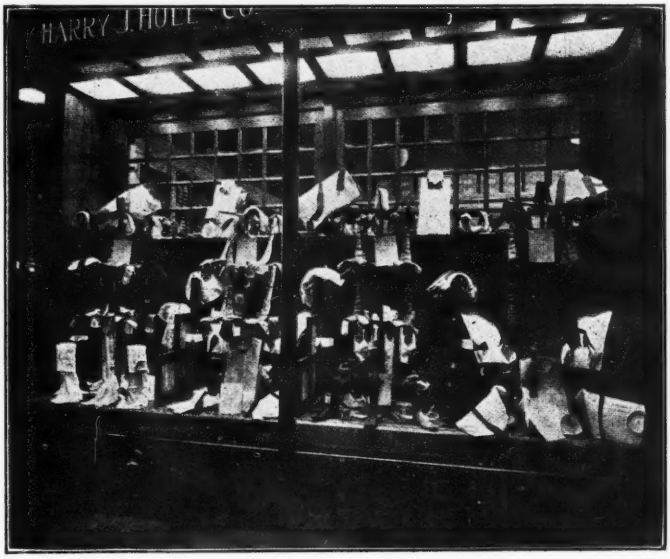


Fig. 1.—Night View (12 minutes' exposure).

The same purpose is served by placing lights of exceptional brilliancy behind certain of the panels; we then obtain the moderate distributed illumination usually required *plus* special intensity in certain directions with the object

of drawing attention to certain varieties of goods.

Besides the advantages already mentioned it is very convenient to have all the lights arranged in the easily accessible manner shown in Fig. 2, which enables any number of lamps to be turned on or off, mantles to be replaced, &c., without disturbing the contents of the window. It is also possible to arrange for several alternative methods of distributing the lamps placed above the diffusing screen, according to the nature of the goods to be displayed in the window.

It will be seen that in this case each burner is equipped with a reflector intended to concentrate the light on the goods below. It would, of course, also be possible to arrange for the sources in question, besides lighting up the goods through the ground glass, to illuminate horizontally a transparent sign carrying the name of the shop, and placed above the window.

In Fig. 2 the general plan of the connexions is shown. The pipe enters at the floor and runs across above the window supplying the various lights

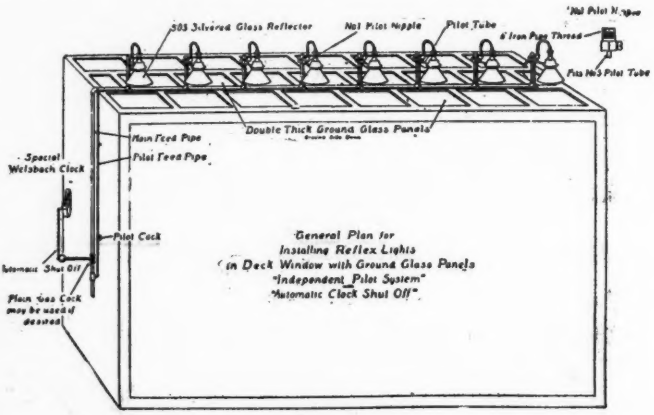


FIG. 2.

employed. Each burner is fitted with an independent shut-off cock. The main supply-pipe is fitted with a special ball-weighted cock, to which is attached clockwork arrangement arranged in such a way that the gas is cut off automatically at a certain prearranged time when no longer required.

Co-operation in Street and Shop Lighting.

BRILLIANT lighting is now recognized to be one of the best advertisements. Mr. James Seager, in *The Business Man's Magazine*, recently referred to the plan of action adopted by the traders who banded themselves together in order to make the general lighting of their street as attractive as possible.

In some cases extra posts were actually erected, but the authorities were inclined to take exception to these, on account of obstruction to traffic. In other cases the plan of arranging brackets carrying lamps on the sides of the houses of the tenants acting together was adopted.

Passers-by involuntarily select a brilliantly lighted street in preference to a comparatively gloomy one, especially when indulging in shopping by night. It is therefore contended that the cost of such exceptional lighting is amply compensated for by the amount of business done.

The Use of Flame and other Arc Lamps for Exterior Illumination.

By Prof. E. W. Marchant, D.Sc.

As a comparatively small number of results of test made on the modern flame arc-lamps have been published, the figures obtained in some fairly complete trials on these lamps, with a view to determining their suitability for street illumination, may be of interest. These tests were carried out with a view to determining the actual gain in efficiency obtained by using a modern yellow or white flame carbon arc-lamp in place of one of the older pattern lamps. The first point of distinction between a flame lamp with inclined carbons and the ordinary arc is the light distribution. In the ordinary vertical carbon arc the maximum illumination occurs at an angle of from 40 degrees to 60 degrees below the horizontal, the exact angle for maximum illumination depending on the length of arc used. In the inclined carbon lamp the maximum intensity of illumination is in a direction vertically underneath the arc. Curves obtained for two typical lamps are shown in Fig. 1, *a* and *b*.

This alteration in distribution of light is a disadvantage for exterior illumination, since it gives maximum effect immediately below the lamp, *i.e.*, on the ground which lies nearest to the source of light, with the result that the surface illumination obtained with such lamps is patchy, being very bright directly under the lamp, and rapidly falling off the farther one goes from it. Although in most of these lamps when the globes are in position the vertical light is almost entirely cut off, there is still a tendency

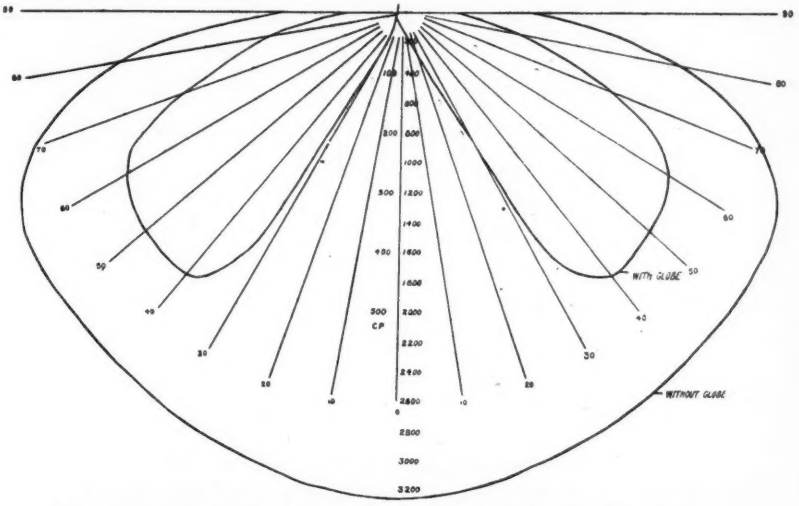


Fig. 1a.—Flame Lamp Yellow Light. Average Volts=38, Current=10 Amperes.
Mean Hemispherical Candle-Power=2,650 (without Globe).
" " " =360 (with Globe).

for the illumination to reach its maximum at an angle considerably nearer to the vertical than with the older type of lamp. It may be of interest to compare the illumination curves given with one which has been drawn—Fig. 2—to show the candle-power curve that would be required to give uniform horizontal illumination over a limited area.

The illumination curve has been drawn so that the source of light gives 0·5 candle-feet horizontal illumination over an area 60 ft. in radius, with the lamps supported 40 ft. above the ground at the centre. This curve approximates much more closely to the illu-

	Mean Hemispherical Candle Power.	Watts per M.H.S.C.P.
Yellow Flame Lamp	2,650	·144
White Flame Lamp	1,270	·338
Ordinary Arc ...	620	·69

These measurements were made without globes, the arc taking a current of 10 amperes at a pressure of about 45 volts in each case.

These figures are comparative, the actual values of the candle-power in the flame lamps vary within wide limits for a given lamp, according to the quality of the carbons employed.

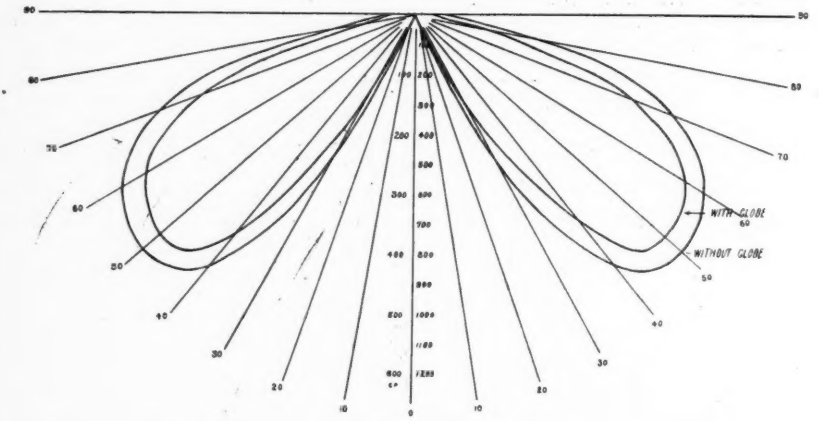


FIG. 1B.—Ordinary Arc double Carbon Lamp. Average Volts=47, Current=10 Amperes. Mean Hemispherical Candle-Power=745 (without Globe).

mination curve given by an ordinary arc-lamp than to that given by the flame arc-lamp with inclined carbons, and shows clearly that a lamp with vertical carbons is much more suitable for street illumination.

The increase of efficiency with the flame lamps is well known, but some of the figures obtained may be of interest. For the sake of comparison, the mean hemispherical candle-power has been determined, although the magnitude of the mean hemispherical candle-power is far from being an adequate criterion of the suitability of a lamp for general illumination.

Some of the flame lamps tested, however, burnt with remarkable steadiness, particularly those giving a yellow flame; in this respect they are now not at all inferior to the older ordinary carbon lamps.

Besides testing these lamps without globes, a number of observations were made with the globes in position. The "globe" tests are liable to a certain amount of inaccuracy, since, with a globe, the source of light becomes scattered, and the square law by which the candle-power was estimated does not hold, except at great distances from the lamp. With the globes used

on the flame lamps the light was usually reduced to about one-sixth of its former value, though in some cases the absorption of the globe was even greater, the light emerging being only one-tenth of that actually produced by the lamp. Making a corresponding comparison with globes in position the figures are :—

It may at first sight appear remarkable that the makers of flame lamps should use globes which practically neutralize the gain in candle-power obtained by using the flame arc. These globes, however, are very brilliant and conspicuous objects when the lamp is burning, and where a lamp is used (as it is in many cases) for

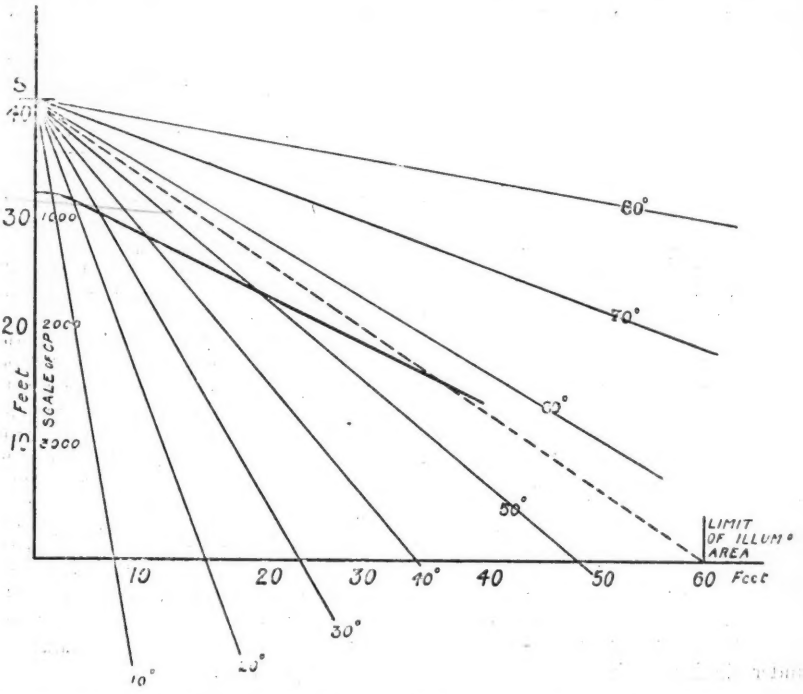


FIG. 2.—Polar Curve showing Candle-Power required to give Uniform Horizontal Illumination of ·5 Candle Foot over a Limited Area from a Single Source (S).

	Mean Hemispherical Candle Power.	Watts per M.H.S.C.P.
Yellow Flame Lamp	360	1·05
White Flame Lamp	200	2·15
Ordinary Arc ..	190	2·25

It will be seen that the flame lamps under these conditions are very little better than ordinary arc-lamps, and have hardly as high an efficiency as some of the modern metallic filament glow-lamps

spectacular purposes the brilliance of the globe becomes of practical utility. At the same time where illumination is wanted it is obvious that a comparatively clear globe should be used. For street lighting, where the lamps are placed high and well out of the direct line of vision of a person in the street, a slightly obscured or even a clear globe might well be employed. If the lamps are low the glare from an arc in a clear globe is, of course, very dazzling, and a dense globe becomes a necessity. Under most conditions it

is clearly of no advantage for the electrical engineer to attempt by every means in his power to give, let us say, 10 per cent. more light for a given supply of energy to his arc-lamps, when the illuminating engineer absorbs 90 per cent. of the total that is produced in the globe.

A point of some importance in connexion with street illumination is the colour of the light used. It is a well-known fact that, on the whole, a reddish coloured light has far greater penetrating power in a fog than one of a white colour. This point may be very clearly seen by a casual observer noticing the distance at which yellow flame lamps and ordinary arc-lamps remain visible in foggy weather. Yellow lamps are visible at a distinctly greater distance than those giving a white light. It is exceedingly difficult to get any actual comparisons between the penetrability of different coloured lights on account of the variations that are liable to occur from time to time in the amount of light that a lamp gives, but there can be no doubt of the greater effectiveness of yellow flame lamps burning under these conditions. This point is one which deserves further consideration from illuminating engineers. In some rough tests made in Liverpool it appeared that the effective illuminating power of a yellow flame lamp in a fairly dense fog was about 30 per cent. greater than that of a white light lamp burning under similar conditions.

It is to be hoped that flame lamps will lead to the more extended use of electric light for street illumination; many lamps of this kind have already been erected. Unfortunately, in lamps intended for street illumination, in which it is essential that the time of burning without retrimming shall be as long as possible, very little care appears to have been taken to avoid losses by absorption, due to auxiliary appliances inside the globe. Lamps of this description are now fairly common, and many of them are of great ingenuity in design, and are admirably constructed; but it cannot be too strongly urged that the essential quality of a lamp is to produce as much light for a given expenditure of energy as possible, and though long burning is of equal (possibly of even greater) importance than efficiency care should be taken that long burning is not obtained at too great a cost.

The development of the flame lamp has been most remarkable, and the operation of these lamps reflects great credit on those who have been responsible for their development; the modern flame arc, when compared with the unsteady flame arc used in the laboratory ten or more years ago shows a wonderful advance, but the limit of efficiency is very far from being reached. and it is to be hoped that lamps of this type will continue to progress until they hold an indisputable position as the most efficient means of illumination that we have.

A High-Pressure Flame Arc.

A RECENT number of the *Journal für Gasbeleuchtung* contains a description of a new form of carbon arc-lamp. The article refers to the fact that the spectrum of the lamp closely resembles daylight, and the results of some recent tests at Charlottenburg are given. The most interesting feature of the lamp, however, is the high P.D. across the arc, which approaches 80 to 90 volts.

The Production and Utilization of Light.

Luminous Efficiency and the Mechanical Equivalent of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 379.)

C. *Spectrum Integration Method.*—As before stated, this method was introduced by Tyndall, who employed it to estimate the radiant efficiency of the electric arc. A spectrum was formed of the source under test and the distribution of energy obtained by moving a line thermopile from end to end of this spectrum. In this way a curve such as is shown in Fig. 2 is

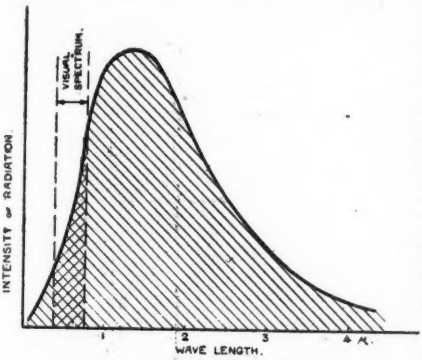


Fig. 2.—Total and Visible Radiation.

obtained. It is then only necessary to find the area of the curve between the two visual limits ·38μ and ·76μ, and to divide this by the total area of the curve from end to end, to obtain the radiant efficiency. The chief precaution necessary in this case is to form the spectrum by a device which gives no absorption or anomalous dispersion, and this is best satisfied by rock salt or carbon bisulphide. In this way Tyndall found a radiant efficiency of 7·7 per cent for the arc, as against 10 to 11 per cent by the absorbing screen method.

The only accurate measurements that have been made by this method are those of Langley* in 1881 and later. In this case the spectrum was formed by a reflecting grating, which eliminated any difficulties as to absorption, &c., and the radiation was measured by the bolometer, which, although discovered in principle by Svanberg in 1851, was first developed by Langley into an accurate measuring instrument. Langley does not, however, appear to have determined the radiant efficiencies from his curves, but Prof. Kapp has recently done this,† and found a value of about 4·5 per cent for the arc.

The method above described is extremely tedious and difficult to carry out, but it may be considerably simplified by forming the spectrum, and recombining either the whole of it or the luminous portion only, on the thermopile. This procedure was adopted by Angström in determining the mechanical equivalent of the Hefner lamp, as described below.

Table I. is a collection of the values of the luminous efficiencies obtained by various experimenters.

Mechanical Equivalent of Light.—For the determination of this quantity three methods have been employed:—

1. Measurement of total power per unit of light and total efficiency.
2. Measurement of total radiation per unit of light and radiant efficiency.
3. Measurement of power and luminosity of a beam of definite composition.

* 'The Bolometer and Radiant Energy,' *Proc. Am. Acad. of Arts and Science*, Jan. 12th, 1881; 'The Actinic Balance,' *American Journal of Science*, xxi., p. 187, 1881; 'On the Selective Absorption of Solar Energy,' *Phil. Mag.*, 1883, p. 153; Langley and Very on 'The Cheapest form of Light,' *Phil. Mag.*, 1890, p. 260.

† Discussion on 'New Incandescent Lamps,' *Proc. I.E.E.*, Jan. 10th, 1907, p. 232.

TABLE I.—LUMINOUS EFFICIENCIES, COLLECTED VALUES.

Source.	Observer.	Date.	Method.	Total Efficiency. Per cent.	Radiant Efficiency. Per cent.
Candle	Thomsen ...	1863	A	0·3	2·1
Oil Flame ...	Melloni	1833	A		10
	Thomsen ...	1863	A		2·06 to 2·11
	Wedding ...	1905	A		0·029
	Lux	1907	A	0·25	1·23
Hefner Lamp ...	Lux	1907	A	0·103	0·89
Gas Flame ...	Tyndall	1862	A		4
	Thomsen ...	1863	A		1·84 to 2·11
Incandescent Gas	Lux	1907	A	0·46 to 0·51	2·03 to 2·97
Acetylene Flame	Angstrom ...	1902	A		5·6
	Nichols & Coblentz ...	1903	C		3·3 to 4
	G. W. Stewart	1902	C		4
	Lux	1907	A	0·65	6·36
Glow Lamp ...					
Incandescent ...	Melloni	1833	A		2
Platinum	Tyndall	1862	A		4·17
Carbon Filament	Merritt	1889	B	·5 to 7·2	
	Russner	1907	B	·58 to ·61	
	Wedding ...	1905	A		0·34
	Lux	1907	A	2 07	2·7 to 3·2
Nernst	Ingersoll ...	1903	C		4·7 falling to 3·6
	Wedding ...	1905	A		0·85
	Lux	1907	A	3·85 to 4·21	5·7
Tantalum	Russner	1907	B	2·2	
	Lux	1907	A	4·87	8·5
Osmium	Russner	1907	B	2·3	
	Wedding ...	1905	A		0·62
Osram	Russner	1907	B	2·46	
	Lux	1907	A	5·36	9·1
Arc Lamp ...	Tyndall	1862	A		10 to 11
	Tyndall	1862	C		7·7
	Nakano	1889	A		1·48 to 8·1 various angles
	Marks				2·3 to 16·2
	Wedding ...	1905	A		0·318
D.C. Arc	Lux	1907	A	5·6	8·1
D.C. enclosed Arc	Lux	1907	A	1·16	2·0
Flame Arc, yellow	Lux	1907	A	13 20	15·7
Flame Arc, white	Lux	1907	A	6·66	7·6
A.C. Arc	Lux	1907	A	1·9	3·7
Mercury Arc ...	Geer	1903	A		40·8 to 47·9
Uviol Mercury Vapour	Lux	1907	A	2·24	5·8
Quartz Lamp ...	Lux	1907	A	6·00	17 6
Vacuum Tube ...	Drew	1903	A		23·4 to 48·6

It is evident that whenever observations have been made, accompanied by measurement of the power consumption of the source, a value for the mechanical equivalent of light can be deduced. Thomsen* thus obtained values of about ·3 watt per candle-power for the mechanical equivalent of the light from candles and other flames. Tumlirz and Krug—from the results of two experiments on the total radiation and radiant efficiency of incandescent platinum wire—gave ·17

* *Loc. cit. ante.*

and ·19 watt for the mechanical equivalent of the light of the hefner lamp.

The most scientific attempt hitherto at the determination of the mechanical equivalent is that of Angström,* who used the apparatus shown in Figs. 3

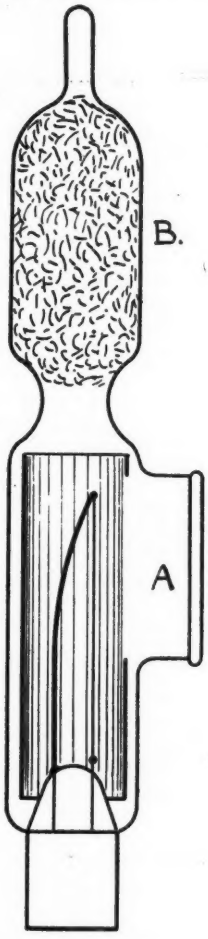


Fig. 3.

and 4. The source consisted of a straight platinum wire enclosed in a special bulb, with a quartz or rock-salt window, and raised to such a degree of incandescence as to match the colour of the Hefner lamp. This source was used in conjunction with the mirrors and prism, and absorbing trough A to form a spectrum at E, where a sharp edge could be traversed by the screw V so as to cut off any given portion of the spectrum. The remainder was recombined by the cylindrical lens C on to the radiometer B or wedge photometer F, which could be introduced into the main body of the apparatus, a Hefner lamp H being employed as standard in measuring the intensity of the beam. The radiometer consisted of the "pyrheliometer," an instrument devised by Angström for absolute measurement of radiation, which will be described elsewhere.

In making the determinations the edge E was set so as to cut off the whole of the radiation of greater wave length than ·76μ, and measurements were successively made of the intensity of radiation, and of luminosity of the beam, resulting in a value of ·1085 watts per Hefner, or ·121 watt per candle. Until quite recently these were the only attempts at obtaining a value of the mechanical equivalent of light, although Merritt has included values of the light power per candle-power in his tables. At normal efficiency this appears to be of the order of ·2 watts per candle, although values in some cases as low as ·14 watt per candle-power were obtained.

It will be noted that in all the previously quoted work, the mechanical equivalent has declined from about ·3 to ·12 watt per candle, as greater care in the cutting of the "dark heat" has been employed. Recently, however, in Germany three workers—Prof. W. Wedding,* J. Russner,† and Dr. H. Lux‡—have obtained values which are extraordinarily low in comparison with all the earlier workers. Wedding

* 'Energy in the Visible Spectrum of the Hefner Standard,' *Phys. Review*, xvii. p. 302, 1903.

* 'Uber den Wirkungsgrad und die praktische Bedeutung gebräuchlichsten Lichtquellen,' *Jour. für Gasbeleuchtung und Wasserversorgung*, 1905.

† 'Luminous Efficiency of Incandescent Lamps,' *Phys. Zeitschrift*, viii. p. 120, Feb. 15th, 1907.

‡ On the 'Efficiency of the most Common Sources of Light,' *Illuminating Engineer*, No. 2, p. 98.

has given values as low as ·0011, or about one-hundredth part of Angström's result; Russner's lowest value is ·02; and that of Dr. Lux ·014. It seems impossible to account for, or to reconcile these values with the earlier ones; and the discrepancies can only be ascribed to the uncertainty which Prof. Nichols has pointed out as attending all absorption methods.

As a correct determination of the mechanical equivalent is evidently of the greatest importance, Mr. Jolley and the writer attempted in the spring of last year to make a direct determination. At the time of doing so we were absolutely unaware of any previous attempt, as nothing appears to have been written on the subject here; and a method was at once devised, which appears to be correct in principle, and which will probably be admitted as the basis on which all such determinations should be made; whether the results obtained are finally accepted or not. The principal object was to determine the mechanical equivalent of the monochromatic yellow-green light suggested by Guilleaume, and thus to be independent of the source or of the properties of any absorbing media whatever.

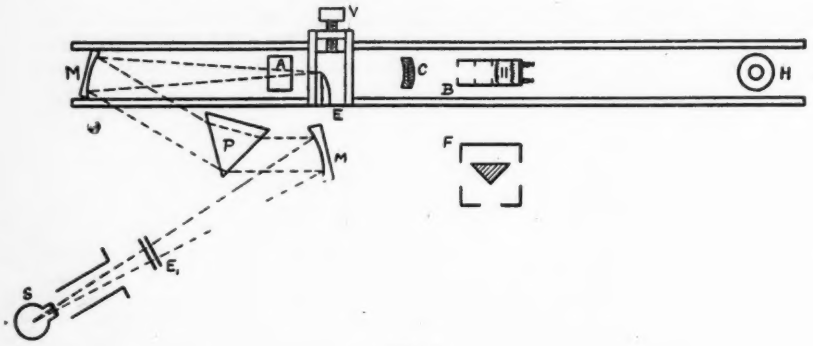


Fig. 4.

(To be continued.)

Obituary.

It is with great regret that we learn of the death of Mr. F. H. Leeds, F.I.C., who was well known both for his general work on photometry and as joint author of a standard text-book on acetylene. Mr. Leeds was among the first contributors to this magazine, and his comprehensive article on 'The Present State of Acetylene Lighting' was one of the last he wrote.

The Development and Prospects of the Metallic Filament Glow-Lamps.

By Dr. Felix Jacobsohn.

(*Continued from* p. 399.)

Besides the patents of Just and Hanaman, there also exist a large number of others dealing with the application of wolfram for the manufacture of glow-lamp filaments. Actually, the use of wolfram for this object is open to anybody, for the first patents bearing on the subject date back as far as the eighties of the last century, and have therefore long since expired (J. G. Willcox, Aldridge, August 11th, 1886, and J. B. Tibbits, October 11th, 1890). The same holds good for the paste process. Consequently all the newer patents are directed to the improvement of existing defects or improved methods of preparing metallic wolfram.

For instance, the wolfram lamp Aktiengesellschaft of Augsburg (German Patents 182,766 of 1904) modify the original substitution process by employing carbon filaments containing wolfram or molybdenum in place of filaments of pure carbon. According to their patent of 1905 (No. 184,379) this firm prepare extremely fine carbon filaments—or, according to the supplementary patent (191,883), filaments containing wolfram and molybdenum —of 0·02 to 0·06 mm. in diameter, which are coated with a layer of molybdenum or wolfram.

Finally, carbides are produced by incandescence in an atmosphere of rarified hydrogen, and these in turn may be either subjected to reduction in water vapour, the carbonaceous material existing in the filaments being thus removed, or the filament may be embedded in wolfram—or molybdenum-dioxide, and heated to 1,600 degrees —to attain which temperature the flame of a blow-pipe suffices. In the last case the process of reduction follows a course which may be expressed by the following relation—

$$WO_2 + 2C = 2CO + W$$

In the supplementary patent No. 193,221, the creation of the carbide and its subsequent reduction are united in a single process involving incandescence in an atmosphere of hydrogen and water vapour. The German patent 185,585 of 1905, taken out by the same company, abandons the use of carbon entirely, the filaments being composed of an aqueous paste of the oxides of wolfram and molybdenum; or the metals, mixed with sulphur or carbon-di-sulphide embedded in clay or magnesia, are reduced in the blow-pipe flame.

The Auergesellschaft of Berlin likewise employ a *small* quantity of water vapour in the reduced atmosphere of hydrogen in order to remove carbonaceous constituents in the filament (German patent 182,683 of 1905). In a more recent patent, however (German patent 194,653), the carbon is no longer removed by the oxidizing action of water vapour, but by the use of nitrogen and water vapour or ammonia; the operation is said to be simpler in this case. The same company (German patent 193,292 of 1906) prepares hollow filaments by rapidly heating the wolfram filaments containing carbon to a white heat. The channel formed in the interior of the filament as a result is proportional to the rapidity with which this temperature is arrived at. One advantage of such a hollow filament is that for a given P.D. a smaller filament is necessary than if it were solid.

The A.E.G., of Berlin, utilized an iron series-resistance in order to compensate for the falling resistance of the filament as it loses its carbon (German patent 188,908 of 1906).

Johannes Lux, of Vienna (German patent 182,967 of 1906), employs an "equalization process" for filaments of wolfram and molybdenum, according

to which the prepared filament is heated in an atmosphere of rarified halogens at a pressure of 0·1 to 1 mm. As a result volatile halogen compounds are formed, which again deposit on the hottest, *i.e.*, the thinner portions of the filament, a cycle of operations which eventually results in the production of an extremely homogeneous filament. In the subsequent patent (German patent 188,509 of 1905) Lux seeks to exhilarate the reduction of a filament composed of a paste of carbon, wolfram, or molybdenum, by the addition of about 0·1 to 0·5 per cent. of aluminium or magnesium. Yet another patent (189,637 of 1906) of Lux advocates the application of aluminium in the form of an alloy of the oxide, in order to improve the ductility of the ensuing product of reduction. According to patents 193,920 of 1905 and 194,894, Lux attempts the production of very fine filaments composed of a paste of wolfram with zinc oxide or sulphide together with an organic binding material. The processes taking place are best represented by the following two equations—

I. $W + ZnO + C = WZn + CO$.

II. $WZn = W + Zn$.

These reactions are accompanied by marked shrinkage on the part of the filament. Cadmium compounds have the same effect.

In the German patent 194,171 of 1906 Lux employs as a binding material completely volatile substances such as camphor.

These processes cannot easily be expected to lead to successful results because, by volatization of the binding material before the melting together of the filament the consistency of the latter is seriously prejudiced.

Francois Jean Planchon, of Paris (German patent 194,896), has the same object in view in employing the albumenoids of molybdenum, wolfram, titanium, and tantalum, which yield gelatinous precipitates with wolfram trioxide, &c.; these in turn can be pressed into absolutely homogeneous filaments.

Siemens and Halske (German patent 194,468 of 1906) heat ammonium wolframate to a temperature of 300 degrees. As a result the ammonia escapes, but a product remains behind which is insoluble in water; it can, however, be worked into a thick paste, which permits of the manufacture of very homogeneous filaments. According to the German patent 195,030 wolfram trioxyhydrate is heated in ammonium until glittering crystals separate out. After heating to 250 degrees these filaments can be worked into a plastic paste with water. In addition the same company (169,928 of 1904) protect the process involving the drawing out of molybdenum, wolfram, &c., into fine wire. In order to secure absolute purity and durability on the part of the metal, and to reduce its inclination to volatize, they advocate the preheating of the same either in vacuuo or in an atmosphere of inert gases, and also describe the preparation of the metal by fusing the oxide, nitride, or hydride. According to the method proposed in their patent number 173,134 they also avoid the consequences of the natural brittleness of wolfram by depositing these metals upon iron. In this ductile condition it can be drawn out into wires, and the iron subsequently removed.

According to German patents 194,349 and 194,682 the brittleness of wolfram and molybdenum can be improved by coating with a layer of ductile metal, this being subsequently removed from the finished filament. Finally, in their patent 181,050 of 1904 they mention the value of alloying tantalum with osmium, wolfram, or molybdenum, the brittle metals being deposited on a tantalum wire, and the want of ductility being thus provided for.

This last patent leads us naturally to discussion of the metal tantalum and its homologues, vanadium, and niobium. Before considering this patent literature in detail, however, which is almost entirely confined to the patents of Messrs. Siemens and Halske, let us briefly pass in review the scientific progress that has been made in the reduction of these refractory metals.

Berzelius* accomplished the reduction

* Poggendorff's 'Annalen,' **22**, 1, 1831.

of metallic vanadium by reduction of the acid with potassium, and also by treatment of the oxychloride $VOCl_3$ by means of ammonia. As Roscoe* had shown, as far back as 1867, only the oxide VO and other lower oxides of vanadium, or else the nitride VN, were obtained by this method. Roscoe therefore endeavoured to accomplish the reduction of this nitride by means of a stream of hydrogen, but achieved no satisfactory results. He therefore turned his attention to new methods, according to which chlorides such as VCl_2, free from oxygen, were treated with hydrogen, or else reduced at a bright red heat with metallic sodium. The resulting product, however, still contained about 1·3 per cent. of hydrogen, and also traces of oxygen; at a white heat yet more marked oxidization occurred.

Moissan's† researches in the electrical furnace only led to the production of the vanadium group, or to the production of the metal containing carbon, which, even under the most favourable conditions, amounted to 4·4 or 5·3 per cent. The aluminium thermal process of Goldschmidt proved quite ineffective for the purpose in view. Somewhat better results were obtained by Weiss and Aichel‡ with the so-called "mixed" metal, aluminium being replaced by an alloy of certain metals of the cerium and yttrium group. Owing to the great reducing power of such an alloy, the vanadium is obtained in the form of a molten metallic regulus of silver-white metal. According to Cowper-Coles§ silver-white vanadium can be obtained by electrolysis of a mixture of 1·75 parts of vanadium pentoxide and 2 parts of sodium hydroxide, with the addition of 32 parts of hydrochloric acid, with a cathode current-density of 0·018 to 0·02 amperes. Gin‖ subjected molten calcium fluoride, placed between a steel cathode and an anode composed of carbon and vanadium tri-oxide, to electrolysis. Vanadium fluoride was then formed on the anode, and metallic vanadium separated out therefrom at the cathode.

Finally, Werner von Bolton* heated rods of vanadium tri-oxide to a white heat by means of a current of 1·8 amperes at a pressure of 42 volts in an evacuated glass vessel. By this means the element was deposited, the recombination of vanadium with oxygen being avoided by the use of a permanent vacuum. By this means the small rods of the oxide were gradually converted into grey, metallic vanadium. As regards the properties of this metal, it may be mentioned that it crystallizes in hexagonal, rhomboid crystals, is white in colour, and is capable of a brilliant polish. It is exceptionally hard, and cannot be scratched, either by steel or force. According to Smith, the metal melts at about 2,000 degrees. Moissan found it more difficult to melt in the electrical furnace than other metals, while von Bolton estimated its melting-point, by the photometrical method of Lummer, to be about 1680 degrees. At ordinary times vanadium is quite stable when exposed to the atmosphere.

It is also exceedingly difficult to isolate niobium from its compounds for it unites very readily with oxygen, and also combines with the substances used in its attempted reduction. The first efforts in this direction may be attributed to Rose,† who succeeded in obtaining the oxide NbO, by the action, under heat, of sodium upon potassium-fluoroxiniobate. Roscoe,‡ by reduction of the vapour of niobium chloride by means of hydrogen, obtained a product which still, however, contained about 0·27 per cent. of hydrogen, and also traces of the oxide and chloride. According to the process of Goldschmidt§ the compound Nb_2Al_3 is formed, while that arrived at by Moissan‖ in the electric furnace contained 2·5 to 3·4 per cent. of carbon.

* Liebig's 'Annalen. Suppl.,' **7**, 70; **8**, 95. *Phil. Trans.*, **159**, 11, 689; **160**, 11, 317.
† *Compt. Rend.*, **116**, 1225, 1893, **122**, 1297, 1896.
‡ Liebig's 'Annalen.,' **377**, 380, 1904.
§ *Eng. a. Mining Journal*, **67**, 744.
‖ *L'Électricien*, **25**, 5, 1904.

* *Zeitschrift für Elektrochemie*, ii. 45, 1905.
† *An. Chim. Phys.*, **54**, 426. *Pog. An.*, **104**, 310, 1858.
‡ *Chem. News*, **37**, 25, 1878.
§ *Phys. Zeitschr.*, 166 and 195.
‖ *Compt. Rend.*, **133**, 20, 1901.

The regulus obtained through the mixed metal by Weiss and Aichel* was, as von Bolton showed, rendered impure by the presence of Nb_2O_5 and the metal referred to. Werner von Bolton, last year, first obtained pure niobium.† He compressed a paste of niobium pentoxide with paraffin into small rods. These were heated to about 1,700 degrees by means of an electric current, the tetroxide of niobium being formed in the process; this in turn was reduced to the metallic state by additional heating in vacuo. The resultant product was extremely pure.

Niobium is of a dull grey colour. Its specific gravity is given as 12·7 to 12·75, and its melting-point is in the neighbourhood of 1,950 degrees. It is fairly ductile, and may be drawn out into wires as thin as 0·05 mm. At a red glow portions of it may be welded together with the hammer. The pure metal is not so hard as soft steel; when traces of aluminium, carbon, or oxygen are present, however, the metal is much harder—almost as hard as vanadium. The electrical specific resistance of niobium, in the form of pressed sheet, is 0·187 (1 m., 1 sq. mm.), but increases with rising temperature in the case of the pure metal. From this standpoint niobium would appear well adapted for the manufacture of glow-lamp filaments. Unfortunately for its application to this purpose, however, the metal has the undesirable property of volatilizing somewhat rapidly in vacuo. As regards the chemical properties of niobium, it is only necessary to add that it forms a refractory oxide and easily volatile chlorides.

Tantalum, the atomic weight of which is given as 181·4, is by far the most important element of this group for the purpose of the manufacture of glow-lamps. As in the case of its homologues, Moissan's researches‡ with the electric furnace only led to a product which contained carbon as an impurity. Goldschmidt and Vautier likewise obtained a product which contained aluminium.*

The researches of Weiss and Aichel† again led to no good results, for the temperature of reaction did not suffice for the production of a satisfactory regulus. Other means of reduction, such as those involving the use of magnesium and zinc, also proved unsatisfactory. The preparation of tantalum in the pure state is also due to Werner von Bolton.‡ Messrs. Siemens and Halske have protected his results in a large number of patents (German patents, Class 49i, 152,848, 152,870, 153,826, Class 40a, 153,548, 1903).

The process of reduction is similar to that described in the case of niobium. Tantalum pentoxide and paraffin are pressed into the form of filaments, embedded in the dioxide, and then reduced to the metallic state, by the so-called pulsating electrolysis, the process taking place in an evacuated vessel which is also subjected to continuous exhaustion in order to remove completely all oxygen. To Werner von Bolton is also due the method of purification involving a modification of the Berzelius-Rose process, in which tantalum powder, obtained from potassium fluortantalate, is employed; on account of its great affinity for all elements in a vacuum, the metal is melted in the electric arc. As a result a shining regulus of platinum-grey metal is obtained. In the truly pure state the metal is so ductile that it can be drawn into wires of only 0·03 mm. in diameter. Tantalum containing 1 per cent. of impurities is still malleable, but already very brittle.

The specific weight of tantalum is about 16·5. It melts near 2,250 to 2,300 degrees. Its modulus of elasticity resembles that of steel. The specific electrical resistance of a length of 1 meter, 1 sq. mm. in cross section, is 0·165, but at a temperature of 1,700 degrees has already risen to 0·855.

* *Lieb. An.*, 337, 384, 1904.

† *Zeitschr. f. Elektrochemie*, 11, 45, 1905; 13, 145, 1907.

‡ *Compt. Rend.*, 134, 212, 1902.

* *Chem. Soc. Ind.*, 17, 543, 1898.

† *Lieb. An.*, 337, 386, 1904.

‡ *Zeitschr. f. Elektrochemie*, 11, 45 and 722, 1905.

According to their first patent (154,527, 1902) Siemens & Halske form filaments from tantalum by the paste process, and derive the metal from the oxides. In supplementary patents, 158,570, 158,571, 164,357, they also utilize the nitrides, sulphides, and carbides. According to another patent (156,714) they increase the resistance of the metal, and reduce the tendency towards volatilization, by previously purifying the filament by the use of hydrochloric and sulphuric acids. In the German patent 159,811 they protect the drawing and forcing out of the electrolytically reduced metal, and in the supplementary patent 165,057 recommend the addition of a trace—no more than $\frac{1}{2}\frac{1}{0}$ per cent.—of carbon, hydrogen, oxygen, silicon, aluminium, tin, or titanium, in order to improve the hardness and durability of the filament. Any addition above this amount must at all costs be avoided, for it leads to great brittleness.

Hitherto the tantalum lamps have proved themselves by far the most durable of the metallic filament lamps. The diameter of the filaments lies between 0·035 and 0·05 mm.; a filament, 0·05 mm. in diameter, intended for a 110 volt 25 candle-power lamp, must have a length of 650 mm., and involves the use of 0·022 grams of the metal. Consequently the horseshoe form filament, characteristic of carbon filament lamps, cannot be utilized. Siemens & Halske have protected the process of winding the filament upon a suitable frame in the German patents 153,328, 159,096, and 168,973.

Tantalum lamps are built by this firm in three distinct types—types A and B being intended for 1·5 to 1·7 watts per H.K., and type C for 2·1 to 2·3 watts per H.K. The temperature of a glowing filament running at 1·5 watts per H K. lies in the neighbourhood of 1,700 degrees. The increase in temperature above this value, necessitated by the attempt at a higher efficiency, would cause the metal to assume a crystalline form and become brittle very rapidly. In the case of the more durable forms A and B, the useful life, during which the light falls off by 20 per cent., reaches about 800 hours; but the actual life before the filament breaks is considerably higher—often double the above value. Reckoning the initial cost of the lamp at 2·50 marks, the maintenance-cost of the lamp thus approaches 0·2 to 0·3 pfennigs per hour of life. On account of the durability of tantalum filaments, which unlike those of the other more fragile metallic filament lamps, can be burnt in any position, it appears that the great shipping companies have now decided to utilize tantalum lamps on their steamboats.*

Let us now refer to the efforts that have been made to utilize the tetravalent metals, zirconium, titanium, and thorium, for the manufacture of filaments. In the first place it may be remarked that, in spite of many experiments, no very practical results have yet been arrived at as regards the use of either titanium and thorium. In addition efforts to obtain zirconium in a pure condition have, up to the present, proved fruitless. For progress in this direction science is greatly indebted to the work of E. Wedekind and his colleagues at Tübingen, whose results have been published in countless communications to the *Berichten der deutschen chemischen Gesellschaft* and in the *Chemiker Zeitung* since the year 1903. Although very many different methods of reduction were attempted the zirconium invariably proved to be impure, and to contain traces of the substances used in the process. In one case, however, Wedekind certainly succeeded in producing an aqueous solution of colloidal zirconium, to which we will refer later.

The most important patents relating to the preparation of and application of zirconium to glow-lamp manufacture are those of Sander of Berlin. Naturally, however, there are many patents in which the use of zirconium is referred to, but the wideness of the claims usually put forward by patentees makes any rigid system of chemical classification of these very difficult. According to a German patent (140,323 of 1901) Sander reduces zirconium or thorium oxide by the use of magne-

* *Chemiker Zeitung*, 1908. 26, p. 336.

sium in a stream of hydrogen. During this process volatile compounds with hydrogen are formed which can be caused to deposit the metal upon a suitable conducting "carrier," when the latter is heated to incandescence in vacuo. Also when zirconium and magnesium are heated together in the electric furnace the resulting product can be treated with dilute nitric acid so as to form a volatile zirconium hydride. The following additional method for the production of this volatile hydride is also given :—

$$ZrCl_4 + 4NaOC_2H_5 = 4NaCl + Zr(OC_2H_5)_4$$

On heating, the volatile hydride is derived from the zirconium alcoholate so produced. The zirconium ethyl obtained by means of the relation—

$$ZrCl_4 + 2Zn(C_2H_5)_2 = Zr(C_2H_5)_4 + 2ZnCl_2$$

also yields the hydride when treated with sodium fluoride.

The other patents of Sander (133,701, 137,568, 137,569, 140,378, 141,353, 146,555, 147,223, 147,316) enable us to perceive that the volatile zirconium compounds cannot be reduced to the metal by the use of carbon with heat, for the essential feature of these patents is the description of processes for the production of carbides. The mechanical portion of the manufacture of glow-lamp filaments from these materials is accomplished by the paste process.

The technical utilization of Sander's patents for Germany was taken up by Dr. Hollefreund & Co. of Berlin. In the case of the carbide lamps so manufactured the diameter of the filament approaches 0·6 mm. and a length of 5 mm. per volt is necessary. Therefore on all ordinary pressures it was necessary to run several of these lamps in series. At a consumption of 1 watt per candle-power they burned for about 100 hours only, and thus exhibited but little mechanical durability. The technical difficulties in the way of the improvement of these lamps proved to be so serious that Hollefreund & Co. finally abandoned the utilization of zirconium entirely, and the so-called "Zircon" lamps practically manufactured by this firm to-day are incorrectly named, for they consist of pure wolfram.

Mention may also be made of the patents of Carl Pieper of Berlin (116,141 of 1898 and 138,468). According to this process filaments of thorium, titanium, &c., are manufactured from titanium, nitride, or graphite of density 2·25, in conjunction with the oxide of thorium, with or without the addition of cerium oxide. By the addition of chromium or wolfram to these metals the melting-point is said to be raised and the general mechanical qualities of the material improved.

The patents of Siemens & Halske (140,088, 140,503, 140,832, 169,565, 169,928, 194,349) relating to this group of metals and also various rare earth metals have already been referred to. When these patents are compared with one another many contradictions become evident. For whereas in the first three patents it is the carbide of thorium that is specially recommended for the manufacture of glow-lamp filaments, the fourth dilates on the advantages of the pure metal; the last patent, however, speaks of thorium filaments containing oxygen, which suggests that the preparation of the metal in a pure state has not yet been accomplished. A great variety of patents relating to the utilization of the carbides of the rare earths for glow-lamp filaments have also been taken out by W. L. Voelker, H. Jehrlant, Konsortium für elektrochemische Industrie, Nürnberg, Dr. W. Nernst, &c., but the discussion of these would carry us outside the scope of the present article.

There exist but a few patents referring to the construction of glow-lamp filaments from boron and silicon either in the form of the pure metal or the carbide. Boron oxide, however, has been added to carbon filaments, with the object of increasing their durability and electrical resistance. André Blondel, of Paris, manufactured filaments from boron and silicon by the aid of the paste process as in 1899 (German patent 115,708). In their patent 195,504 of 1907, the A.E.G. describe a process of fusion in order to improve the conductivity of boron.

The electrical resistance of boron is very high—nearly a hundred times that of carbon; on the other hand,

its decided tendency to volatilize in a vacuum militates against its use for glow-lamp filaments, and its mechanical strength also leaves something to be desired. The boron carbide, on account of its low conductivity, can be added to zirconium carbide with advantage. Too high a percentage of boron carbide, however, results in the filament becoming very brittle, while a filament containing 10 per cent. of boron carbide and 7 per cent. of carbon is mechanically strong, but inclined to volatilize.

Silicon and its carbides exhibit much more promising qualities. Thus a lamp in which the filament is composed of silicon, the so-called "Helion" lamp, has recently been put upon the market, and tests on these filaments have given very favourable results. The filament is prepared by the deposition of silicon from volatile compounds upon a carbon core. Lamps intended for 110 volts consume 1 watt per candle-power, the temperature of incandescence of the filament being given as 1,750 degrees. The life, it is said, often extends as long as 1,270 hours, and invariably over 700 hours.

Finally, reference must be made to the Kuzel process of constructing metallic filaments. This method is protected by the German patents 194,348, 194,890, 194,891, 194,893, and covers the use of all the metals under consideration. The method is really essentially a paste process, but differs from others in the fact that the pure metal is reduced to a gelatinous colloidal condition, thus obviating the necessity for any foreign binding material.

In order to prepare metals in a colloidal state—*i.e.*, simply explained, an exceedingly finely divided condition, in which the surface exhibited is very great—Kuzel utilizes neither the vaporization of a metal by electrical means, nor the primary creation of the desired state by suitably guided processes of reduction. He prefers rather to rely upon chemical methods, according to which metals, already reduced to a finely divided condition by mechanical means, are subjected to alternate treatment with acid and alkali aqueous solutions, and during the process of washing a small quantity enters into solution in the water as a "hydrosol." Wedekind,* for instance, by utilizing a reducing process of this nature, was able to prepare a hydrosol of zirconium by treatment of the zirconium-potassium-fluoride with metallic potassium. By careful evaporation of such "sols" we are able to obtain "gels" of varying consistency which can afterwards be pressed out into exceedingly homogeneous filaments, and can be forced through much narrower apertures than in the case of any other variety of paste.

In consequence of the absolute uniformity in diameter of these filaments, which burn at a consumption of 1 watt per H.K., they can bear an enormous degree of over-running, even as far as 0·31 watts per H.K., without burning out; their useful life approaches 1,000 hours. The practical working of the Kuzel patents is in the hands of Messrs. Pintsch in Germany, and Joh. Kremenezky in Austria-Hungary.

When we reflect upon the evidence of energy and painstaking labour embodied in the array of patents to which reference has been made in this article, and survey the progress that has already taken place in the development both of electric lighting and in the manufacture of incandescent mantles, we cannot doubt but that we are on the eve of a complete solution of the problems that have arisen in the manufacture of metallic filament lamps, formidable as many of them now appear.

* *Chemiker-Zeitung*, 1906, 1,264.

The Photometry of Street Lamps.

By Haydn T. Harrison, M.I.E.E.

The close competition which now exists between the gas and electricity supply undertakings for street lighting is so keen that the respective merits of the competitors can only be judged by actual photometric tests made on the lamps in position. Therefore a few hints as to the ways and means of carrying these out expeditiously and accurately may be of value to the readers of this journal.

Before actually describing the best method of procedure, it would be well to consider the conditions under which the measurements are generally made, and the figures which it is required to know.

Street illumination consists in nearly all cases of a row of lamps supported by posts, generally erected on alternate sides of the road, but sometimes on one side only or down the centre. Therefore the degree of illumination will depend on three factors :—

(1) The candle-power of the useful rays of the lamps. (C.P.)

(2) The distance apart of the lamps. (D.)

(3) The height of the lamps. (H.)

These three factors can be included in one figure, viz., minimum illumination, by the following simple formula :

Minimum illumination in Candle Ft. =

$$\frac{\text{C.P.}}{d^2 + H^2}$$

d^2 being the distance half-way between the lamps, and therefore the furthest distance from any lamp.

$d^2 + H^2$ giving the slant distance from the lamp squared, this figure when divided into the c.-p. of the lamp at that point gives the minimum illumination which combines all the factors it is required to know.



From this it would appear that it is only necessary to make a measurement in the position (P) shown in the sketch —Fig. 1 of which represents an elevation of the street and Fig. 2 a plan— but, unfortunately, in ninety-nine cases out of a hundred it is impossible to make this measurement, as the illumination at that point is generally lower than any photometer can record accurately.

Take, for example, a street lighted by incandescent gas lamps of 50 candle-power, erected on posts 12 ft. high and 120 ft. apart (diagonally). The direct illumination on a photometer screen 4 ft. from the ground at a distance of 60 ft. from any lamp would be :

$$\frac{50}{3600 + 64} = \cdot 014 \text{ C.F.}$$

Or if a horizontal screen photometer were used, thus deriving illumination from both lamps, but at an angle which reduces the degree of illumination in proportion to the cosine of the angle of incidence (which in this example is between 11 and 12 degrees, of which the cosine is ·193) the illumination on the screen would be :—

$$\text{C.F.} = \cdot 193(\cdot 014 + \cdot 014)$$
$$= \cdot 0054$$

As no photometer can be used with any degree of accuracy below ·02 of a candle foot, it is obvious that, even when measuring the illumination direct, it would be unwise to do so at the point of minimum illumination; and in most cases it is a waste of time to attempt it.

My method of procedure is as follows :

I first make careful notes of the height and distance apart of the lamps. It is sometimes difficult to measure the height of the lamps with a tape measure, and therefore the better class of portable photometer is generally provided with some means of ascertaining the angle at which the rays from the lamp strike the photometer—such as a lens or sector. These can be used to calculate the height by placing the photometer

at a measured distance from the post, levelling it, and ascertaining the angle of the rays; then the height will be equal to the distance multiplied by the tangent of the angle.

Having made these notes, the next proceeding is to measure the illumination at the greatest distance from the post that it can conveniently be measured, and calculate the candle-power at that particular angle. This will give very approximately the candle-power of the rays which will strike the point of minimum illumination.

After this, all measurements on that type of lamp can be made at the point most suitable for obtaining accurate readings and rapidity of working.

Taking, for example, the beforementioned case of incandescent gas lamps 12 ft. from the ground and 8 ft. above the photometer screen: the height squared is 64. Therefore, a distance such as 12 ft. from the post, which, when squared and added to 64 equals 208, would prove a good position at which to make the tests on the lamps. Let us suppose that the direct illumination proved to be ·22 candle-feet, which when multiplied by 208 shows that the candle-power is 45·76, or at that position 8·5 per cent lower than it was found to be at the position nearest the minimum, which was higher owing to the horizontal candle-power being greater. This difference being known, measurements can be rapidly made at 12 ft. from the various posts in the street, and the results reduced to the minimum which will occur at any part of the street, provided the distance apart of the various posts is known.

It will be noted that in the above method, which I have found to be by far the most easy and accurate way of surveying the illumination of a street, the actual measurements are made in direct illumination; that is to say, the photometer is pointed so as to receive the rays of the lamp under test at an angle nearly approaching a right angle to the surface of the measuring screen. It is for this reason that a photometer with a screen at forty-five degrees lends itself to rapid and accurate work in practice.

In the above example, when making measurements at 12 ft. from the post, the light from the lamp would fall on the forty-five-degree screen at an angle of which the cosine is ·98; thus the error due to this would only be 2 per cent. Even at a distance of 40 ft. from the post, where the illumination is as low as ·03 c.-f., the angle of incidence would be only thirty-four degrees, which means a correction of 17 per cent; whereas if a horizontal screen is used, the angle at the latter distance would be seventy-nine degrees, and the illumination as low as ·005 c.-f. In this case, an error of one degree in levelling would cause an error of 8·5 per cent in the reading; whilst in the case of the forty-five-degree screen it would only be 1·2 per cent.

When measurements are being made in more important thoroughfares, where lamps of greater candle-power erected

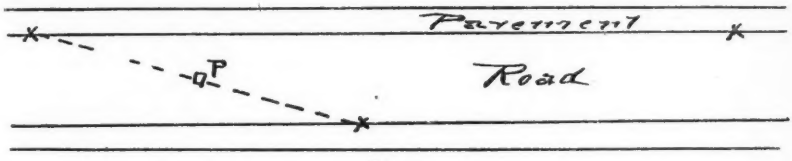


FIG. 1.

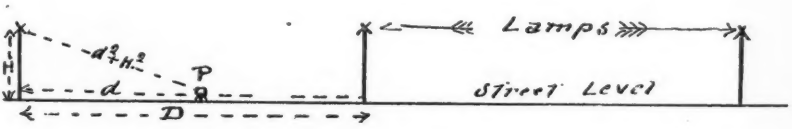


FIG. 2.

on higher posts are used, it is sometimes possible to make horizontal measurements at the point of minimum illumination; but these cases are so rare that the use of a horizontal screen is generally impossible if it is required to know the illumination throughout a street.

On the other hand, the use of a horizontal screen is sometimes preferable when testing the illumination of an open space containing large candle-power lamps irregularly spaced; but even then the candle-power of each lamp cannot be calculated from the results—which is sometimes a serious drawback.

As regards the best type of photometer to use: this does not come within the scope of the present article; but for the benefit of those who have had little experience in photometric work, I would strongly advise the use of a photometer which has a flicker head. This type of photometer can be used to measure the illumination from any kind of lamp, and, moreover, it is possible for any one, however inexperienced, to obtain a balance by eliminating the flicker.

In street photometry the following sources of error should be carefully guarded against:—

1. *Errors due to variation in standard lamps.*—Any other form of standard than an incandescent electric lamp requires the careful attention of an expert, and cannot be used with success except in calm weather. An electric standard can be relied upon, provided all connexions between it and the battery are permanently made; and the necessary switch or plug key which is inserted in the circuit in order to disconnect the lamp is of the most substantial design. It must be obvious to all that these precautions are most important when it is borne in mind that a four-volt battery is used; therefore, the varying of the pressure of a terminal, due to connecting and disconnecting, might easily introduce resistance which varies the P.D. across the lamp by ·05 of a volt—this means over 1 per cent, or often 7 per cent, variation in the candle-power of the standard.

The safest way, therefore, is to use a type of photometer in which the battery is contained in the instrument, and thus the connexions, with the exception of the switch or key, are permanent. After charging the cells the lamp should be connected for at least fifteen minutes; the photometer can then be checked against a lamp of known candle-power. After measurements have been made in the street, the photometer can again be checked against the same lamp to see if any variation has occurred.

2. *Errors due to observation.*—These are often caused by the operator placing his eye too close to the screens, and thus not getting a general view. I find that when using a photometer 4 ft. from the ground, the best results can be obtained by leaning over so that the eye is about a foot above the screens.

When using a flicker head, let it revolve as slowly as is possible, with the object of eliminating the flicker. The speed has to be increased if the spectrum of the lamps vary considerably, but when they are similar the speed can be low. Measurements should not be taken if the eye is fatigued.

3. *Errors due to angular uncertainties.*—These have been touched on before, and are not, as a rule, serious except when a photometer having a horizontal screen is used, when the greatest care must be taken in levelling the instrument.

In conclusion I would endorse the advice so often given to amateur photographers: never be in a hurry. Always make ready before going out, so that as little work as possible need be done in the open. Note-books should be prepared, with columns ruled under headings of the details required, such as distance, height, reading in C.P., angle, type of lamp, position, and general notes. These columns can be filled in by an assistant while the measurements are being made.

With a suitable instrument and ordinary care, the candle-power of the lamps or the illumination of a large number of points in several streets can be measured in a few hours, and from the results all the data required can be calculated and curves prepared if necessary.

The New "Radium" Illuminated Sign.

By W. Biegon v. Czudnochowski.

Illuminating signs used for advertisements and other purposes in the streets by night are now beginning to receive a considerable amount of attention. Naturally such signs attract the attention of the passer-by much more readily than a daylight advertisement would do. During the daytime people are engaged in business, and have little leisure to study their surroundings in the streets. In the evening, on the other hand, their attention is free to wander, and the greater brilliancy of the illuminated sign more readily attracts attention.

Hence it comes about that many forms of illuminated signs are now being devised, and the amount of energy actually consumed in this way is already far from trivial.

It occurred to the author that a description of an ingenious and effective arrangement recently shown at the "Augur" display in Berlin—an exhibition devoted to recent devices for shop-lighting, &c.—might be of interest. The general construction of this "Radium" sign is shown in Fig. 1.

L is a small glow lamp mounted on the end of a horizontal tube, and surrounded by the conical reflector R; in the case of very large signs several lamps may be used. The conducting wires D are passed through to the glow lamp at a right-angle bend in the tube at K. There is a thread on the outer surface of the tube on which are mounted two metal plates P, provided with nuts as shown. These two plates serve to clamp and hold in position the curved metallic framework GG.

This surface GG is a zone of a sphere made up of a network of strips of metal. The glow lamp is placed at the focal length of this spherical framework, so that the beam of light from the reflector R is cast on to the strips of which it is composed.

Under ordinary circumstances emblems or mottoes are cut out of some suitable light-reflecting material. and mounted on this skeleton framework, the usual plan being to place the emblem or trade mark in the centre, and the motto surrounding it. When the lamp is turned on these letters, &c., appear brilliantly illuminated, the surrounding surface appearing dead black in comparison. In

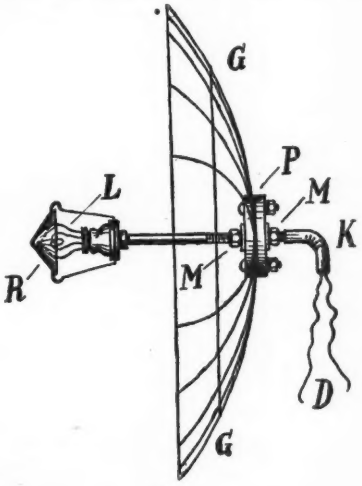


Fig. 1.

order that the signs may be visible from different angles, a substance which diffuses the light in all directions, but yet, at the same time, absorbs very little of it, is employed.

In general, such surfaces present a silver-like appearance, but, of course, trade marks, &c., can be made up in various colours as required.

The effect is to cause the illuminated device to appear as if floating in the air unsupported; the source of light being of small dimensions and, of course, screened from the eye, is not

noticeable at the distance. The general effect of such an arrangement is shown in Fig. 2.

Such a sign is simple and ingenious, and consumes comparatively little energy. Hitherto illuminated signs require a considerable amount of energy.

Secondly, signs may take the form of illuminated transparencies, lanterns, &c., fitted with opal glass or other diffusing surfaces, but these signs commonly absorb a great deal of light.

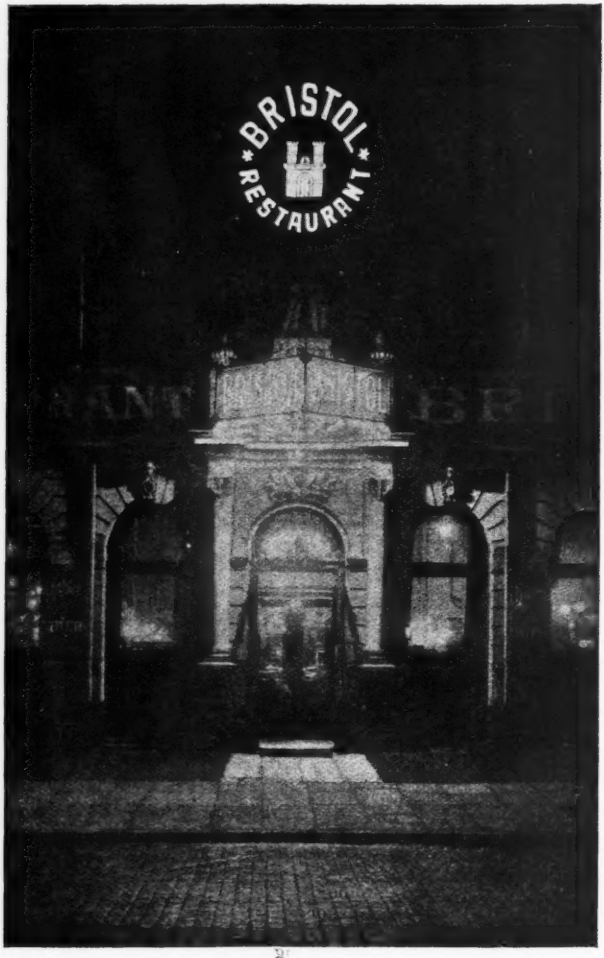


FIG. 2.

have been divisible into two main classes. There is firstly the type of signs outlined in incandescent lamps, which are frequently turned on and off at intervals by a special mechanical contrivance. Such signs, however, The newly patented "Radium" sign certainly seems to produce very effective results, and consumes a relatively small amount of energy, while the loss of light by absorption is reduced to a minimum.

Gas-Lighting at the Scottish National Exhibition, Edinburgh.

By W. R. Herring,

Chief Engineer to the Edinburgh and Leith Corporation's Gas Commissioners.

Gas-lighting plays an important part in the illumination of the Scottish National Exhibition, which was opened on May 1st by H.R.H. Prince Arthur of Connaught, and it will no doubt be of some interest to briefly state what has been done to demonstrate the efficiency and economy of coal gas for both exterior and interior illumination for such and similar purposes. To simplify the description the subject is sub-divided into the following headings, viz., Exterior Illumination, Interior Illumination.

candles per foot of gas consumed, with a clear glass globe. The lamps are suspended within a harp-shaped attachment surmounted upon a dwarf column supported upon the pedestals of the entablature of the bridge, the centre of the light being 14 ft. above the carriage-way. The area of the roadway lighted is not great, measuring in all 3,546 superficial feet. The total illumination given by the lamps is 3,168 candles or ·89 candles per square foot of area illuminated for a consumpt of 84·8 cubic feet of gas, costing 2¾*d.* per

A. Vesta-Graetzin—3-Light Lamp (Clear Globe).

Pressure on Burner. Tenths.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
25	15 0	17 9	45	1·17	9·8	368	37·44
,,	,,	,,	,,	1·19	10·2	374	36·7
,,	,,	,,	,,	1·21	10·2	382	37·4
,,	,,	,,	,,	1·13	15·9	357	22·5
30	15 0	17 9	45	1·26	10·6	396	37·4
,,	,,	,,	,,	1·11	11·4	349	30·6
25	4 0	15 1	4	1·17	10·2	266	26·0
,,	,,	16 2	3½	1·11	15·9	289	18·2

Remarks.—At 25 tenths the consumpt was reduced to 8·8 cubic feet per hour, but no photometric test was taken on account of the loud noise made by the lamp. Similar conditions prevailed at 30 tenths on reducing the consumpt below 10·6 cubic feet per hour.

The last two tests (viz., at angles of 4° and 3½°) are as near horizontal as possible without cutting off part of the light with the lamp shade.

Exterior Illumination.

The main entrance is approached by a bridge spanning a river. The bridge is lighted by means of eight Vesta-Graetzin inverted self-intensifying lamps with three burners and mantles in each, supplied by Messrs. Falk, Stadelmann & Company, Ltd., London.

These lamps were found to give, when photometrically tested, their best results when regulated to a consumpt of 10·6 cubic feet per hour each at thirty tenths pressure, and gave a total of 396 candles per lamp or 37·4 hour and yielding 1,132 candles per pennyworth of gas consumed.

The statement of our tests of these lamps in Table A conveys some interesting information.

The entrance gateway, offices, and turnstiles, &c., are lighted by means of incandescent gas lamps supplied by Messrs. J. & W. B. Smith and Messrs. Moffats, Limited.

Each central archway is fitted with a Nero-Graetzin five-light inverted lamp supplied by Messrs. J. & W. B. Smith, some of these lamps being also

in use in other parts of the exhibition not specifically mentioned. When subjected to photometrical investigation they were found to give their best results when regulated to a consumpt of 14·1 cubic feet at thirty tenths pressure, and gave a total of 580 candles per lamp, or 41·1 candles per cubic foot of gas consumed, with a clear glass globe. The maximum candle-power obtained from these lamps was 607 candles at a consumpt of 15·25 at twenty-five tenths pressure, but the efficiency per foot is only 39·8 at this consumption. (See Table B.)

B. NERO-GRAETZIN—5-LIGHT LAMP (CLEAR GLOBE).

Pressure. Tenths.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
25	15 0	17 8	45	1·75	13·9	543	39·0
,,	,,	,,	,,	1·81	14·3	567	39·6
,,	,,	,,	,,	1·94	15·25	607	39·8
30	,,	,,	,,	1·87	14·1	580	41·1
,,	,,	,,	,,	1·90	15·2	594	39·1
25	3 6	16 1	3	1·56	15·25	404	26·5
30	3 5	16 0	,,	1·50	14·2	386	27·2

Remarks.—At 30 tenths with a less consumpt than 14·1 cubic feet per hour the light decreased, and no photometrical test was taken.

The last two tests (viz., at angle of 3°) were taken as nearly horizontal as possible without cutting off part of the light with the lamp shade.

The Stanley inverted lamps supplied by Messrs. Moffats, Ltd., are of their well-known type, and used at the entrance gateways and offices, and also in the kitchen of the first-class restaurant, and gave, when photometrically tested and the gas pressure regulated to twenty-five tenths at a consumpt of 8·3 cubic feet per hour, 338 candles or 40·7 candles per foot of gas consumed, and the data (Table C) regarding these will be interesting.

Immediately upon passing the entrance portico to the exhibition one has access to the main avenue leading to the Grand Promenade.

The lighting of these areas has been entrusted to Messrs. James Keith & Blackman Company, Ltd., who have installed one of their well-known high-pressure plants. The engines and compressor plant are situated in a small building to the left of the entrance portico. Messrs. James Keith & Blackman Company, Ltd., have introduced for this purpose for the first time their new single burner inverted lamp of a guaranteed candle-power of 1,500 candles. Along the avenue placed alternately on either side twenty-four single lamps are erected, spaced from 29 to 70 ft. apart, the breadth of the avenue being 40 ft., and there are twenty-one three-cluster lamps surrounding the grand promenade, which

C. STANLEY 3-LIGHT LAMP.

Pressure Tenths.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
25	15 0	17 2	45	1·12	10·0	332	33·2
,,	,,	,,	,,	1·2	9·3	350	37·6
,,	15 1	17 4	,,	1·12	8·3	338	40·7
,,	15 2	17 5	,,	1·0	8·2	310	37·8
,,	15 2	17 5	,,	0·86	8·2	262	32·0

Remarks.—The first three tests were made with a clear globe and reflecting shade.

The fourth test with clear globe, without reflecting shade, and the last with opal globe without reflecting shade. The loss of light with the opal globe is therefore 15·5 per cent.

measures 580 ft. long by 300 ft. wide. It may be stated that the principal exhibition buildings are placed around the Grand Promenade, thus forming a quadrangle. There is a further number of forty-one single-burner lamps on the same system lighting other avenues and areas within the exhibition grounds. The lamps are suspended from a swan-neck attachment secured to the top of the column. The mantle, it may be interesting to note, measures $3\frac{5}{8}$ in. long by $1\frac{1}{2}$ in. diameter. One of these lamps tested in the first instance yielded 1,630 candle-power for a consumption of 24·5 cubic feet of gas per hour, which is equal to 66·5 candles per cubic foot. As on this occasion, the grand promenade are of an exactly similar type to those already described. The total area of the quadrangle is 174,000 square feet, and the total candle-power 106,155. This illumination is equal to ·61 candles per square foot of area lighted, and yields 2,230 candles per pennyworth of gas consumed.

Band-Stand.

The band-stand in the centre of the quadrangle is illuminated by means of twelve Nero-Graetzin two-light lamps supplied by Messrs. J. & W. B. Smith. Each lamp is controlled to work at twenty-five tenths pressure by a service governor, and when photometrically tested was found to give

D. Photometrical Tests on Keith's New High Pressure Inverted Lamp—1 Mantle Light, Mantle $3\frac{5}{8}$ inches long by $1\frac{1}{2}$ inches diameter, slight bulb shape.

The normal quality of the gas would be 20 to 21 candles when burnt in a No. 2 Metropolitan Argand Burner, and the calorific power of the gas at Granton 648·3 gross, 598·9 net, and at the Testing Station 560 net.

The test was taken by a Simmance & Abady's Street Photometer, which had been previously verified by testing a given lamp simultaneously on a 100 inch Bar Photometer and the Portable Photometer in the same room and under like conditions.

29th April, 1908.

Pressure Inches.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
61	4 6	40 0	$2\frac{1}{2}$	1·05	24·6	1,683	68·4
61	16 0	42 4	20	0·95	24·6	1,705	69·3
61	20 0	29 9	37	1·81	24·8	1,609	64·9

Remarks.—Clear globe. Slight leak in the meter, which did not affect the index when the burner was shut off, but which may have affected the consumpt.

however, the mantle was not found to be suitable for the size and shape of the flame, and the test was purposely carried out in order to enable the makers to adjust both the nipple of the lamp and get a properly shaped mantle for the particular purpose; further tests were made at a later date when the lamps were delivered for the exhibition proper. These results are set out in Tables D and Da.

The area of the avenue along which some twenty-four single lamps are placed measures 45,527 square feet, and the total candle-power emitted is 40,440 candles; this is equal to an illumination of ·88 candles per superficial foot of area dealt with. The twenty-one three-cluster lamps around its best results when regulated to consume 6·2 cubic feet of gas, yielding 218 candles, or 35·2 candles per cubic foot of gas consumed, with *a frosted globe*, and the following statement of tests convey some interesting information. With all lamps burning $74\frac{1}{2}$ cubic feet of gas per hour is consumed, costing about $2\frac{1}{2}d.$, and giving 2,616 candles or 1,066 candles for one pennyworth of gas consumed. (See Table E.)

It may be interesting to note that Messrs. Rosie & McKelvie's automatic lighting and extinguishing device has been introduced experimentally into the band-stand installation.

The device is one that is actuated by a change of pressure, the lighting

and extinguishing being brought about by a momentary reduction of pressure, and is capable of adjustment to a considerable extent. One leading feature of the arrangement is the means by which the bye-pass flame is extinguished during the period that the lamp is burning, this being accomplished in a very ingenious way. The apparatus is in process of being patented, and therefore a more definite description cannot at the moment be given.

GROUNDS AROUND OLD HALL.

The lighting of the grounds around the Old Mansion House south of the main exhibition buildings is accomplished by means of ordinary lamp-posts fitted with swan-neck connexions, to which are suspended five-light inverted Pharos lamps, supplied by Messrs. W. Anderson & Co., Ltd., Edinburgh. They are supplied with gas from the ordinary town main at a pressure of thirty to thirty-five tenths. There are in all twenty-eight of these lamps.

These lamps photometrically tested gave their best results when regulated to twenty-five tenths pressure and a consumpt of 15·4 cubic feet, yielding 560 candle-power, or 36·3 candles per foot of gas consumed, with a clear glass globe. It must, however, be pointed out that these lamps are still deficient in that perfection of method of regulating which applies to some of the other lamps referred to, and that the results vary when testing different lamps. This point is worthy of the makers' attention. (See Table F.)

DA. PHOTOMETRICAL TESTS ON KEITH'S NEW HIGH PRESSURE INVERTED LAMP—1 MANTLE LIGHT, MANTLE 3⅜ INCHES LONG BY 1½ INCHES DIAMETER, SLIGHT BULB SHAPE.

30th April, 1908.

Pressure Inches.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
61	4 9	40 0	4	1·04	22·9	1,655	72·2
61	16 0	42 1	20	0·95	22·9	1,685	73·6
61	20 0	28 9	37	1·9	22·9	1,572	68·6

Remarks.—Clear globe. A slight leakage in the pipe amounting to 0·09 feet per hour, which has been allowed for.

E. NERO-GRAETZIN—2-LIGHT LAMP (FROSTED GLOBE).

Pressure Tenths.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
25	10 0	10 4	45	1·43	5·4	153	28·3
,,	,,	,,	,,	2·04	6·2	218	35·2
,,	,,	,,	,,	2·04	7·7	218	28·3
30	,,	,,	,,	1·94	6 1	208	34·1
,,	,,	,,	,,	2·13	6·8	228	33·5
25	4 0	15 11	5	0·62	6·2	156	25·2
,,	,,	,,	,,	0·60	7·6	151	19·9

Remarks.—All the above tests were taken with a ground glass globe.

At 30 tenths on reading the consumpt below 6·1 there was a marked decrease of light, and therefore no photometrical test was taken.

The last two tests (viz., at angle of 5°) are as near horizontal as possible without cutting off part of the light with the lamp shade.

INTERIOR LIGHTING.

At the outset gas-lighting appeared to have a poor chance at the exhibition for any purpose. Fortunately for both the authorities and also for the industry wiser councils prevailed, and a reasonably fair share of lighting has been

allocated to the gas commissioners. Although at one time it had been definitely arranged that the whole of the interiors were to be electrically lighted, negotiations resulted in gas being adopted somewhat largely. It was, however, only on the basis of competitive estimating, and these remarks apply to the whole of the succeeding lighting installations, for each of which competitive estimates were submitted by both the gas commissioners and the electrical contractors; the cheaper estimates were for gas, the estimates in all cases being based on candle-power and cost per hour for illumination as well as equipment.

The principal feature of the interior lighting is the illumination of the Fine Art Section.

This consists of nine galleries, which the gas commissioners took under their especial care. The lamps selected for the lighting of these galleries is the three-light "Empire" inverted lamp of Messrs. J. & W. B. Smith fitted with frosted globes and arranged as follows :—

In each gallery a double line of pipes is laid upon the roof structure, each line being placed 8 ft. 6 in. from the wall upon which the pictures are hung. Depending from this pipe lamps are suspended 11 ft. apart, this method being applied to all nine galleries, with the addition that in the central gallery three additional lamps are suspended, as the same is of much higher pitch, and is intended for statuary as well as pictures. The double line of lamps in each gallery is shielded on the outer side with a curved-shaped screen so as to prevent the light from one side of the room reflecting in the pictures on the opposite side. The central gallery, in addition to the "Empire" lamp, is fitted in the centre with a thermopile Lucas lamp, which has been kindly lent by Messrs. Moffats, Ltd., London, for the purpose. This lamp has already been fully described in the technical press, and one need not, therefore, say more than that this, like others, was submitted to photometrical tests, and was found to give a candle-power of 1,814 candles, burning gas at the rate of 40 cubic feet per hour, and 45·3 candles per cubic foot, with a clear glass globe, the lamp being upright in form with a single mantle measuring about 6 in. by 1½ in. A note of the tests taken upon this lamp is given in Table G.

F. PHAROS—5-LIGHT LAMP (CLEAR GLOBE).

Pressure Tenths.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
25	15 0	17 9	45	1·6	14·7	502	34·1
,,	,,	,,	,,	1·78	15·4	560	36·3
,,	,,	,,	,,	1·86	16·3	586	35·9
,,	,,	,,	,,	2·10	18·5	658	35·5
,,	3 9	13 4	4	2·10	16·0	372	23·2

Remarks.—Tests taken with clear globe.

The last test (viz., at angle of 4°) is as near horizontal as possible without cutting off part of the light with the lamp shade.

One of the mantles showed signs of sooting after about one hour's burning.

There is no means of regulating the air supply.

On either side of the thermopile lamp a five-light Pharos inverted lamp is fitted, supplied by Messrs. Anderson, and similar in every way to those erected by the same firm in the gardens.

The lighting and extinguishing of the lamps in the art section is under central control. Each lamp is fitted with one of Messrs. Alder & Mackay's automatic distance lighters. This device is actuated both for lighting and extinguishing by momentarily raising the pressure, or, so to speak, sending forward a pressure-wave of from eight to ten tenths in excess of the normal. The gas supply is controlled by means of a Peebles governor, and the lamps adjusted to give their highest efficiency

at a pressure of twenty-five tenths, the pressure in the district mains ranging from thirty-two to thirty-five tenths. A bye-pass is introduced between the inlet and the outlet of the Peebles governor controlling the entire building, and the lighting and extinguishing of the entire installation is accomplished by opening the bye-pass stopcock for a period of from one to two minutes and then closing it again. The extinguishing is brought about by an exactly similar operation.

This system of lighting and extinguishing has been found to answer admirably, and is peculiarly well adapted to installations where the control is desirable or can be established from one or more centralized positions, and the pressure-wave impulse made to reach all points, either from a station governor or from a localized governor on small gasholder.

with a clear glass globe. The particulars in Table H of our tests on this burner will give some useful information.

Regret may be here expressed that circumstances prevented our testing all of the lamps with clear glass shades.

G. LUCAS—THERMOPILE—1-LIGHT LAMP (CLEAR GLOBE).

Pressure Tenths.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
25	5 1	33 0	4	1·66	40·0	1,814	45·3
,,	,,	,,	,,	1·33	35·0	1,450	41·4
,,	,,	,,	,,	1·05	30·0	1,145	38·1
,,	15 0	29 7	25	1·63	35·0	1,426	40·7
,,	20 0	24 6	45	1·94	35·0	1,168	33·3

Remarks.—Tests taken with clear globe. This burner makes a whirring noise.

Attention may, however, be directed to the paragraph beneath the statement of tests of the "Empire" lamps where it is brought out that the loss of light by photometrical test consequent upon using a frosted globe instead of a clear glass amounted to 15½ per cent. As a matter of fact, I am of opinion that the frosted or satin finish globe is by far the most satisfactory for interior lighting, and that, whilst there is an apparent loss photometrically observed, it is a question whether the diffusion and more equal distribution does not more than compensate for the apparent loss of light. The softness of the light and the slightly yellow tone resulting from the use of ground glass is much more pleasing, and on the whole better appreciated by the public.

H. EMPIRE—3-LIGHT LAMP.

Pressure. Tenths.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
25	15 0	17 6	45	1·16	7·75	355	45·8
,,	,,	,,	,,	0·96	7·10	294	41·4
,,	,,	,,	,,	0·98	7·75	300	38·7

Remarks.—With the Gas Regulator fully open the consumpt was 7·75, so no test with a higher consumpt could be taken.

The first two tests were taken with a *clear globe*, the last test being taken with a ground glass globe causing a loss of light equal to *15·5 per cent.*

The "Empire" lamps, when photometrically tested gave their best results when regulated at twenty-five tenths pressure to pass 7·75 cubic feet of gas per hour, yielding 355 candles, or 45·8 candles per foot of gas consumed,

The floor area of the galleries lighted (taking one gallery as an example) is 2,640 square feet, and there are sixteen

three-light "Empire" lamps fitted in each, giving a total illuminating power of 4,800 candles, with frosted globes, which is equal to 1·8 candles per square foot of floor area illuminated. The total illumination in the whole of the galleries works out at 47,934 candles, with frosted globes, and the consumpt of gas at 1,233 cubic feet per hour, which at 2*s.* 9*d.* per 1,000 cubic feet equals 3*s.* 4½*d.* per hour, or equal to nearly 1,178 candles per one pennyworth of gas consumed, or by using clear glass about 1,400 candles per one pennyworth of gas consumed could have been obtained.

I. NULITE—1-LIGHT LAMP (CLEAR GLOBE).

Pressure.	Consumpt.	Candle-power.	C.P. per foot.	Remarks.
15	2·56	67·00	26·17	
,,	2·46	67·00	27·23	
,,	2·35	61·50	26·17	
,,	2·68	70·00	26·12	
,,	3·19	65·00	20·38	Regulator fully open, special test at 3½ ft. consumpt.
20	3·06	79·00	25·82	
,,	2·85	79	27·72	
,,	2·69	74	27·51	
,,	2·50	66	26·40	
,,	3·54	74	20·90	Special test at 3½ ft. consumpt.
25	2·80	74	27·14	
,,	2·96	81	27·37	
,,	3·15	84	26·66	
,,	3·59	81	22·56	Special test at 3½ ft. consumpt.
30	3·16	88	27·85	
,,	3·03	87	28·71	
,,	2·94	82	27·89	
,,	3·53	90	25·49	Special test at 3½ ft. consumpt.
35	3·12	88	28·20	
,,	2·96	84	28·38	
,,	2·86	77	26·92	
,,	3·54	92	26·00	Special test at 3½ ft. consumpt.
15	3·54	78	22·03	
20	4·00	76	19·00	
25	4·02	80	19·90	
30	4·03	78	19·35	
35	4·04	83	20·54	Regulator fully open.

Remarks.—This lamp is in appearance similar to the Graetzin, but unlike the latter *has no means of regulating the air supply.* The gas regulating nipple *is not* placed immediately over the centre of the lamp as is usual, but is at the side, the gas being conducted over the "Crown" of the lamp, down the side, and thence to the burner. The lamp is fitted with a chimney contained within the globe as in the Graetzin.

PRINCE'S RESTAURANT AND WELCOME CLUB.

The Prince's Restaurant and Welcome Club, consisting of reception-room, dining-hall, smoking and retiring rooms, and verandah are also lighted by gas at low pressure, controlled by means of a Peebles governor to twenty-five tenths pressure at the outlet, the lamps employed being adjusted to give their maximum efficiency at this pressure.

In this building Messrs. J. & W. B. Smith's two- and three-light "Empire" lamps and their single burner "Nulite" lamp are installed. Here the lamps are fitted in pairs and actuated by means of pneumatic distance lighters so that they may be switched on and off at will.

The test of some of the lamps installed have already been referred to, but the following statement relating to the "Nulite" burner contains a

good deal of information. This lamp, when photometrically tested, was found to give its best results when the gas was regulated to a consumption of 3·03 cubic feet per hour at thirty tenths pressure, yielding 87 candles, with clear glass, or 28·71 candles per foot of gas consumed. It may be remarked that this lamp does not contain the regenerative or pre-air heating device which most of the other lamps already dealt with embody. It does ensure a fresh or unvitiated air supply by a bunsen tube; its results are not however, so good as where the air supply is not only unvitiated, but pre-heated in its access to the mixing chamber, and furthermore it is a lamp that requires a greater pressure for its highest efficiency. (See Table I.)

lamps, and along the two sides by twelve one-light "Pharos" lamps, the latter actuated by pneumatic switches. The total area of the hall is 4,620 square feet, and the total candle-power 3,752 candles, giving an illumination of ·81 candles per square foot of area. The gas consumption per hour for this section is 104 cubic feet, costing under 3½*d.* per hour, or 1,093 candles per one pennyworth of gas consumed.

The single burner "Pharos" lamp gives a high efficiency, but considerable variation on testing different burners. This arises primarily from the want of means of adjustment in the inner chamber where the gas and air meet. The following tests, however, of this particular lamp when carefully adjusted

K. PHAROS—1-LIGHT LAMP.

Pressure. Tenths.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Foot Candles at Photometer Disc.	Consumpt Cub. Ft. per Hour.	Candle-power.	C.P. per Cub. Ft.
	ft. in.	ft. in.	°				
30	—	7 6	Horizontal.	2·25	3·52	126	35·7
30	11 1	10 0½	45	—	3·52	125	35·5

Remarks.—These tests were taken with white porcelain cone in position. The lamp will *no* burn *without* this cone.

The make of these lamps is not yet quite satisfactory, as the means of adjustment are not as easy as will be necessary to ensure the lamp the success that it deserves on the market, as in testing other lamps of the same class considerable variations are discovered in the quality of the mixture at the burner. The makers will do well to give these points their serious attention.

The area of the principal rooms lighted is about 5,578 square feet, and a total of 3,128 candles is provided; this is equal to ·56 candles per square foot of area. The gas consumption per hour amounts to 97 cubic feet, which at 2*s.* 9*d.* per 1,000 cubic feet works out at about 3¼*d.* per hour or 977 candles per one pennyworth of gas consumed

GENERAL DINING ROOM AND RESTAURANT.

The above restaurant, &c., situated to the south of the Industrial Hall, consists of large dining-hall, side wings, kitchen, service rooms, &c. This establishment is lighted by "Pharos" lamps supplied by Messrs. W. Anderson & Co., Ltd., Edinburgh, similar to those already referred to. The dining-hall is lighted along the centre by means of four five-light "Pharos"

by ourselves will show that it is of a promising character. (See Table K.)

INDUSTRIAL HALL, RESTAURANT, AND BAR.

The above restaurant and bar, situated on either side of the main entrance to the Industrial Hall are also lighted by incandescent gas on the low pressure system controlled to a pressure of twenty-five tenths by a Peebles governor. These lamps are of the "Nulite" pattern by Messrs. J. & W. B. Smith.

The total area of the restaurants amounts to 5,050 square feet, and the total candle-power is 2,523. This gives an illumination of ·50 candles per square foot of area, and a gas consumpt of 88 cubic feet per hour, or less than 3*d.* per hour, or 870 candles per one pennyworth of gas consumed.

There are other minor sections of the exhibition where gas has also been installed as well as to a number of the stall-holders. They are mostly, however, fitted with lamps of the classes already dealt with, and need not be further referred to.

Saughton Hall.

Saughton Hall, an old mansion house which forms part of the exhibition, is used as an administrative block, and for exhibits of the artisan section, wherein specimens of handicraft of all trades and the work done by the technical schools of Scotland are exhibited in various rooms, as well as a section in connexion with the Japanese Education Department.

This Hall was previously lighted by means of coal gas in the old-fashioned manner, but has been refitted throughout for lighting by means of incandescent burners of the inverted type, viz., two- and three-light "Empire" lamps, and single burner lamps supplied by Messrs. J. & W. B. Smith.

Altogether some ninety-four lamps have been fitted in the various rooms, yielding 12,427 candles of illumination for a consumption of 323 cubic feet, or at 2*s.* 9*d.* per 1,000 cubic feet, costing a little more than 10½*d.* per hour for the entire illumination of this building, which is equal to 1,170 candles of illumination per one pennyworth of gas consumed.

Taking one of the principal rooms as an illustration the area lighted is 1,122 square feet, and the candle-power 1,370 candles, which is equal to 1·22 candles per square foot of area lighted.

Memoranda.

The preceding statements of tests need a few words of explanation in order that a true value may be put upon the results obtained.

In the first place, the gas used would read 20 to 21 candle gas when tested on a No. 2 Argand burner, and would have a calorific value of 560 net. The tests were taken in a large workshop, and the lamps to be tested were screened on three sides by a large black painted framed screen which completely cut off light rays from the walls of the building, which were by no means white, and the roof, which was black. There might be some slight reflection from the floor, but no more than would result from the ordinary ground surface, where the lamps are normally installed.

The apparatus employed was one of Simmance & Abady's street photometers, adjusted and verified by testing a known lamp simultaneously on a 100-inch bar photometer, and also on the Street photometer situated in the same room at the same time.

The general scheme of lighting was devised by Mr. A. C. Freeman, C.E., Chief Engineer to the Exhibition Committee, and in planning it he has provided for an ample flood of light, both as regards electricity and gas, believing that brilliant lighting is a source of attraction to the public, and adds a charm and fascination for the purposes in view.

The lighting generally was placed in charge of the Machinery and Lighting Committee, of which Mr. James T. R. Wilson, the Convener of the Lighting Committee of the Edinburgh Corporation (who it will be remembered has done so much to bring Edinburgh into the front rank so far as its street lighting is concerned), is also chairman, and the following gentlemen members: Prof. Beare; Prof. Barr, Glasgow; Mr. Douglas; Mr. Alexander Gracie, Govan; Mr. C. N. Kemp, B.Sc.; Mr. W. H. Massie; Mr. McMichael; Mr. Newington, City Electrical Engineer; Mr. Hugh Reid, Glasgow; Mr. Simon Slater; Mr. George A. Scott; Prof. Stanfield; Mr. James Thomson, C.E.; Mr. W. B. Walker; Councillor J. T. R. Wilson, Convener; Mr. W. R. Herring; and upon an official inspection of the lighting the day previous to the opening of the exhibition all expressed their admiration of what had been accomplished.

Table L, giving the candles per square foot of area illuminated and the number of candles per pennyworth of gas consumed at 2*s.* 9*d.* per 1,000 cubic feet, is rather interesting when taken comparatively.

It will be observed that the principal restaurants are allocated one-half candle per superficial foot of floor area dealt with, and it may be remarked that this is an ample amount of light in such places and in dwelling-houses and offices. It is, however, a little remarkable to find the whole of the exterior illuminated with a greater degree of light than the interiors, excepting, of course, in this instance the art galleries. I have found from experience that the half-candle of illumination per superficial foot of area covered in an ordinary-sized room is ample, lighted from the centre. The inverted lamp invariably gives its best results at an angle of at or about 45 degrees. Taking an ordinary room, say 18 ft. square, centrally lighted, the height at which the fitting would be placed would throw the greatest degree of light on the floor at the skirtings, and ensures the most perfect distribution and illumination. The cost per 1,000 candles of illumination also referred to on the same table is of interest, and is a most striking instance of the enormous advance that has been made from the days when three candles per foot of gas consumed burned in the best type of then known burner, viz., the Metropolitan Argand, and which is still the standard by which coal gas illumination is officially measured.

L. Statement giving the degree of Illumination in Candles per Square Foot of Area dealt with and the Number of Candles of Illumination per One Pennyworth of Gas consumed.

Area Lighted.	Candles per Square Foot.	Candles for One Pennyworth of Gas.	
Entrance Bridge	0·89	1,132	Clear Glass
Royal Avenue	0·88	2,230	,,
Grand Promenade	0·61	2,230	,,
Fine Art Gallery	1·95	1,178	Frosted Glass
		1,400	Clear Glass
Industrial Hall Restaurant ...	0·50	870	,,
Prince's Restaurant	0·56	977	,,
General Dining-Room	0·81	1,093	,,

Some Important Forthcoming Events.

At the meeting of the Verband Deutscher Elektrotechniker at Erfurt on June 11th, 12th, and 13th, several papers of special interest relating to electric lighting and illumination are to be read. Among these we notice that of *Prof. W. Wedding* dealing with recent progress in electric illumination, and two papers by *Herr Remané* on the effect of overrunning on metallic filament glow-lamps, and a comparison between the upkeep of small arc lamps and high candle-power osram lamps. *Drs. Schanz* and *Stockhausen* will contribute a paper dealing with the effects of light on the eye.

The meeting of the Institution of Gas Engineers in this country will be held from June 16th to 18th: subsequently, by the invitation of the Deutsche Verein von Gas-und Wasserfachmännern, the English members will pay a visit to Berlin, returning to England on June 24th.

We note that the annual meeting of the Dutch Gas Association will take place at Breda on July 8th.

The fifth International Acetylene Congress is being held in London on May 28th, 29th, and 30th, when delegates from the various countries will attend, and addresses will be delivered by Sir Wm. Ramsay, Mr. F. S. Thorn, and others, and will be followed by visits to various installations of acetylene lighting.

Artificial Illumination and the Education of Those Concerned in its Production.

By Charles W. Hastings.

(*Continued from* p. 206.)

Although it is not absolutely essential that the student should have served his articles in the office of a gas engineer, or his apprenticeship in a gas-works, a knowledge of the theory and practice of gas manufacture is imperative. We do not premise that the illuminating engineer shall be a maker of gas, but that he should be able to employ the illuminant (which is brought to the door of the house) in the best and most economical manner.

It will, of course, be necessary that he should be able to make the usual tests for illuminating power, calorific value, and specific gravity; also to test the purity of the gas which he is going to use for illuminating purposes. Therefore practical photometry must be one of his earliest studies. If the illuminating engineer is to be anything more than a glorified gas-fitter he must also be able to measure light, *in situ*, and so arrive at a definite idea of the requirements for buildings of varying propertions (heights and areas). He should be able to make photometrical tests of burners of all kinds, and to this end it will be necessary to thoroughly grasp the notifications of the Metropolitan Gas Referees, to which we called attention in a previous number.

A slight knowledge of the chemical constituents of coal gas will probably have been acquired; if not, we recommend the close study of Butterfield's 'Chemistry of Gas Manufacture.'

Flame temperature must have careful attention; we know of no treatise upon the subject, but a very admirable lecture was delivered, in June, 1905, before the members of the Institution of Gas Engineers, by Prof. Arthur Smithells, B.Sc., F.R.S., on 'The Temperature of Flames.' We commend this lecture to the consideration of all interested in illuminating engineering.

Another branch for inquiry and research is air supply to burners, and the best point at which it shall mix with the gas. Opinions differ much: some makers of burners go so far as to bring an independent high pressure air supply to the point of ignition; generally burners of the bunsen type—be they upright or inverted—have a mixing chamber. The regulation of the quantity of both air and gas are matters of economical consideration, both in the intensity of illumination and the consumption of gas. Very carefully constructed regulators are attached to many incandescent burners. In the writer's opinion those made upon the needle governer principle are the best. Here, again, the aid of the illuminating engineer is needed by the consumer; these admirable helps to the better use of gas are purchased by the public, but their practical application not being understood, the beautiful mechanism of the regulator is soon put out of gear, and the last state is worse than the first.

An establishment, large or small, lighted with gas should have the supply pressure regulated on the street-main side of the meter, and the pressure of the gas supplied to the house standardized; in such a case all difficulties of gas and air supply could be overcome, the regulators set, and uniformity of illumination ensured.

A standard pressure is desirable, and a service from the main of a sufficient diameter to supply the maximum quantity of gas needed; this should be attached to a governor or regulator, and then coupled up to a meter of the size necessary to measure the maximum quantity of gas consumed. It is no unusual thing for twelve or fourteen "points" to be fitted with burners, with gas passing through a five-light meter—this should never be permitted. Service pipes are very

commonly too small to permit of the necessary flow of gas. Interior pipes and fittings are often ridiculously small. An establishment to be lighted with gas should have a rising main from the meter to the top floor, and trunk mains should be taken from it to supply the fittings on each floor.

In Walter Hole's book, 'The Distribution of Gas,' we find the following table, which gives the size of service pipes usually laid for the number of lights specified :—

¾ in.	Service	up	to	10 L'ghts
1 "	"	for		10 "
1¼ "	"	"		20 "
1½ "	"	"		50 "
2 "	"	"		80 "
3 "	"	"		150 "

It will be noted that no pipe of less dimension than ¾ in. is scheduled; the author assumes that the services should not exceed 100 ft. in length.

Some useful instructions upon the point under consideration will be found in the last edition (1904) of Newbigging's 'Handbook for Gas Engineers.' In the section devoted to 'Internal Fittings' Mr. Newbigging suggests a series of regulations to be issued, by gas companies and others, to those undertaking the fitting up of houses or other buildings for gas, and gives the sizes of meters and their measuring capacity, &c. :—

Size of Meters.	Size of Inlet and Outlet.	Measuring Capacity per Revolution.	Measuring Capacity per Hour.
Light.	In.	Cub. ft.	Cub. ft.
2	½	⅒	12
3	½	⅛	18
5	¾	¼	30
10	1	½	60
15	1	¾	90
20	1¼	1	120
30	1¼	1½	180
50	1½	2½	300
60	1½	3	360
80	1¾	4	480
100	2	5	600
150	3	7½	900

To ascertain the number of lights which any size of meter will supply, divide the measuring capacity per hour by the quantity of gas per hour which each jet is estimated to consume. Example: What number of lights, consuming 4 cubic feet of gas per hour, will a 20 light-meter supply ?

$$\text{Then } \frac{120}{4} = 30 \text{ lights.}$$

With regard to the sizes and lengths of pipes to be used for ordinary house lights Mr. Newbigging gives the following table :—

Internal Diameter.	Greatest Length allowed.	Greatest No. of Burners allowed.
In.	Ft.	Number.
⅜	20	3
½	30	6
⅝	40	12
¾	50	20
1	70	35
1¼	100	60
1½	150	100
2	200	200

It has now become general to fit up with iron pipes, but the illuminating engineer will be probably consulted with reference to the gas-lighting of houses or premises that have been fitted up for many years; in such a case it is quite certain that he will discover a network of small lead or composition pipes with strange elbow joints and T unions. His first work should be to strip them all out. Instances have been met with, in our own experience, of a five-light chandelier, each burner consuming at least 5 cubic feet per hour, being supplied with gas through a ¼ in. composition pipe.

We have touched upon several matters more or less relevant to the education of the illuminating engineer, viz. :—

1. That some knowledge of gas-making and the chemistry of coal-gas is desirable.
2. A study of the temperature of flame, air supply, &c., is necessary.
3. A knowledge of the science and practice of photometry, the estimating of consumption of burners and intensity of illumination under varying conditions is imperative.
4. That attention be given to the size of service pipes, flow of gas, pressure regulation, capacity of meters, and dimensions of internal pipes and fittings.

(To be continued.)

SPECIAL SECTION.

Illumination at the First Municipal Exhibition.

THE first Municipal, Building, and Public Health Exhibition was opened on the 1st and closed on the 12th of May this year. During the exhibition a series of lectures dealing with various subjects of interest to municipal authorities were given, and the Editor of *The Illuminating Engineer* was invited to assist in bringing the subject of illumination before the public notice. Two lectures dealing with this subject were delivered by Mr. Leon Gaster and Mr. J. S. Dow respectively, and were followed by actual demonstrations of the measurement of illumination.

The object of these lectures, which we reproduce in this section, and the demonstration by which they were followed, was to show that this subject is really of vital importance to the general public, and that methods of actually measuring light and illumination are now available, which are quite sufficiently accurate to justify the more general reliance upon actual systematic measurement instead of mere ocular demonstration.

For the purpose of the demonstrations referred to a lofty room at the Agricultural Hall was illuminated by Messrs. The New Inverted Incandescent Light Co., Ltd., and the Agricultural Hall Co., Ltd., who kindly fitted up a series of the latest flame arc-lamps and incandescent gas-lamps. The illumination was then measured at various points in the room, experts being present to explain the action of the various illuminometers shown working. Those present were extremely interested in the use of these instruments, and to many of them it came as a surprise to discover how comparatively simple measurements of illumination have now become.

We take this opportunity of thanking all those who came forward at such short notice to assist in the display of apparatus. Thanks are due firstly to those mentioned above for kindly arranging for the illumination of the King Edward Hall by means of incandescent gas-lamps and flame arc-lamps respectively. Mr. Haydn Harrison and Mr. Kenelm Edgcumbe kindly undertook to be present at the demonstration of the use of the illuminometers with which they are connected.

We have also to express our acknowledgment of the courtesy of Mr. Lancelot Wild and Messrs. Sugg for arranging for the exhibition of the Wild flicker photometer, and also to Messrs. Sugg for lending an example of the Harcourt 10 candle-power pentane standard for exhibition. Also to Messrs. Elliott, Ltd., and Messrs. Everett, Edgecumbe & Co., Ltd., who kindly sent representatives to demonstrate the working of the Harrison and Trotter illuminometers. Messrs. Franz, Schmidt, and Haensch, of Berlin, also kindly sent an interesting collection of instruments for exhibition, including the Martens illuminometer, two types of Bechstein contrast and flicker photometers, the Thorner apparatus for testing daylight illumination, the most recent form of Lummer-Brodhun photometer head, &c. Dr. C. H. Williams, of Boston, also kindly sent an example of the Simplex illumination - photometer. Thanks are also due to Mr. C. C. Patterson and Mr. J. W. Blakey for lending a number of lantern slides.

Among the many others who expressed their interest in the exhibition and indirectly contributed to its success we may mention the names of Dr. Biegon von Czudnochowski, Dr. Krüss, Dr. Martens, Prof. Ulbricht, and Dr. W. Voege in Germany, and Dr. Louis Bell, Dr. Hyde, and Mr. P. S. Millar in the United States.

Some Lighting Exhibits at the Municipal Exhibition.

Among the various exhibits relating to lighting by gas and oil, we may mention that of the Praed Safety Gas Light Co. The gas in question consists mainly of air, containing a very small admixture of petrol-vapour, and is prepared by means of the plant shown in Fig. 1. The hot-air motor A, worked by a burner using the safety gas, actuates the small petrol pump C and the air-propeller B, and thus forces the air into the chamber D; here it comes in contact with a very fine spray of petrol, and becomes mixed with the vapour. E is the tank holding the required amount of petrol.

It is claimed that the petrol-air gas so produced burns with an intensely hot flame, which suffices to bring an incandescent mantle to bright incandescence and to enable the gas to be used for heating and cooking. It is also stated that the gas is non-poisonous, non-explosive, and, owing to the fact that it contains practically all the air necessary to support combustion, uses a negligible amount of the air of the room it is used to illuminate. We are also given to understand that it is possible to secure a light of 75 C.P. for one hour, with a consumption of petrol only costing about one-fourteenth of a penny, *i.e.*, at the rate of about one penny per candle-power hour.

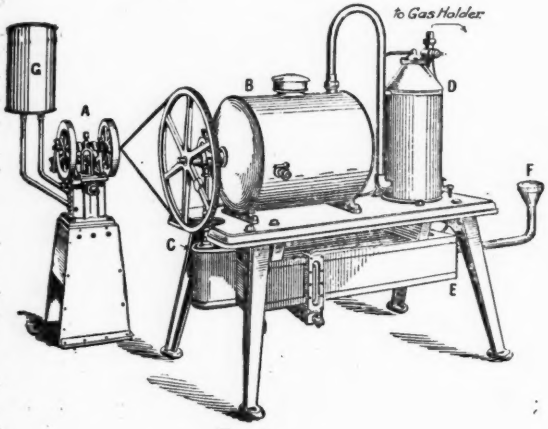


Fig. 1.

Messrs. R. Stephens & Sons, of Clevedon, exhibited their automatic light controller, an example of which is shown in Fig. 2. In order to save the waste of labour involved in the constant turning on and off of street-lamps by hand, it is now becoming customary to utilize a change of pressure at the gasworks in order to control automatic lighting-up devices of the nature attached to individual lights. It may often be desired, for instance, to extinguish at a certain hour at night all but certain lights at definite intervals down the streets. The exact behaviour of this controller can be modified considerably; it can be adjusted either to light up with a given increase in pressure, and, independently, to extinguish at a specified diminution in pressure, or to light up with a certain increase in pressure, and then to extinguish by the next subsequent increase of the same nature.

Another light-controlling automatic device exhibited was the time-switch of the Automatic Light Controlling Co. of Bristol. This can be applied to extinguish automatically the arc-lamps used in street-lighting at any predetermined time.



Fig. 2.

Messrs. Parkinson and W. Cowan, Ltd., of Birmingham, also exhibited a number of examples of lanterns for street-lighting, lamp-columns, brackets, &c., as well as their special anti-vibrator, which, it is claimed, provides for both lateral and vertical vibration, and is now extensively used.

Among other exhibits mention may be made of the exhibit of the "Ironclad" mantles made by Messrs. Curtis & Harvey, Ltd., of Deptford, for which special durability and strength is claimed, and the petrol-air gas plant of the De Laitte Gas Co., Ltd.

Efficient Illumination and Municipal Requirements.

(Lecture delivered by Leon Gaster at the Municipal, Building, and Public Health Exhibition on May 6th.)

THERE are a number of aspects of the subject of illumination which are of vital importance to the public at large and to those interested in municipal affairs in particular. Immense sums of money are spent annually in the illumination of streets and public buildings of various descriptions in which the ratepayers are directly interested. There are countless public halls, libraries, hospitals, asylums, &c., where the need for good and efficient illumination make itself manifest.

My object to-night is to impress upon those responsible the urgent need for paying due attention to the need for better illumination in municipal affairs. I firmly believe that neglect of this matter, either in the direction of useless extravagance or mistaken and false economy, has a wide and far-reaching effect upon our national welfare, and, as I shall endeavour to show later, may well be responsible in many cases for injury to health to an extent that is not generally realized.

This leads me to allude firstly to one question which has been giving grave concern to the medical profession, and which will readily be admitted to be, at any rate, of the greatest national importance. I refer to the question of the eyesight of the children in our schools. It seems to be placed beyond doubt by the researches of authorities in this country, on the Continent, and in the United States, that a very serious deterioration in eyesight makes its appearance in children during their passage through the school-life. I do not doubt that improvements in our system of education might effect a partial remedy of the existing conditions, but I wish to emphasize the stress that has been laid by all those in the medical profession who have recently taken up the subject upon the value of *good illumination*. In this connexion I may quote a few results on the subject which were recently summarized in a special section of *The Illuminating Engineer* (Jan. and March, 1908).

Dr. Kerr, Medical Officer to the L.C.C., has recently issued a report which deals with the lighting of schools in London, and the eyesight of school-children at work therein. He particularly emphasized the need for a good illumination in the case of children who are called upon to make special mental efforts at a critical period in their physiological development.

"A normal person of middle age," he says, "will distinguish characters on paper in a poor light with greater readiness than a small child, because the characters are more familiar to the adult, and so much more easily recognized. Conversely a child requires a better light to learn to read by than does an adult, to whom reading is second nature. From a large number of experiments the least illumination permissible on the school-desk of a child has been found to be equal to 10 candle-metres."

Dr. Kerr lays down simple rules of illumination which, he says, ought to be insisted upon in schoolrooms, and quotes the results of a number of tests, according to which it appears that of 163 schools visited, the artificial lighting of 20 per cent. were classed as only fair, while 29 per cent. were classed as really bad. The daylight illumination was likewise condemned in many cases, 27 per cent. of the schools visited being described as fair, and 25 per cent. as bad.

Miss Sayer, also an Assistant Officer to the L.C.C., has likewise pointed out how school life does, in some way, interfere with the salutary develop-

ment of eyesight. In the London schools alone there are nearly a million children, and of these at least 25,000 are actually seriously handicapped by defective vision.

Lastly I may refer—only selecting two among the many authorities who have made consistent statements on this point—to the work of Prof. Scott in the United States and Dr. Hubert Biss, who recently contributed an article to *The Illuminating Engineer* on this very subject. Prof. Scott traces the development of eyesight in the schools in America since the alarming figures published by the United States Bureau in 1881. He is convinced that the evils referred to are partially due to defects in illumination which might easily be avoided, and winds up with the following conclusion :—

"Because of the lack of attention which is paid to the light actually present in the school-rooms, and because of the great difficulty in adjusting our windows and shades to the varying intensities of the external sources of light, it is not surprising that we should find in our school-rooms conditions of light so bad that during many hours and days reading of ordinary printed matter without undue strain upon the eyes is impossible."

Dr. Biss fully confirms the significance of the deterioration in eyesight in school life, and points out how essential not only good, but *very good* illumination in our schools must be.

In the face of this consistent evidence I do not think that I can be accused of attaching undue importance to the matter. Many different authorities have reported on the subject, and all tell the same tale. We know that the eyesight of school children does suffer. We know that the illumination in schools is often put down as inadequate. And we are, therefore, justified in feeling that this defective illumination is at least a partial cause of the existing trouble and ought to be remedied. It also stands to reason that even where defects of eyesight do not make their appearance, the effort and strain of working under a bad illumination must leave its effect on the general health and well-being of the worker. I have dwelt specially on this section of my lecture, because I think it is of special importance to municipal authorities. I wish to advocate the establishment of a really systematic testing of not only the eyesight of children in schools, but also of the conditions of illumination which are prevalent. The present moment is particularly opportune. For the first time this year the Board of Education directly concerns itself with the medical inspection of school-children. This inspection will include the examination of eyesight. Let it be also extended to include a critical examination of the illumination. I am convinced that the data accumulated in this way would be of inestimable value, and would enable us to determine in what exactly the present defective conditions consist and how they are to be remedied. It must also be remembered, too, that even when the illumination in a school is excellent the parents or guardians must be interested in order that the illumination at home may be equally good.

The question of eyesight leads me to speak next of the illumination of our public libraries. Here again the constant strain to which the eyes of readers are necessarily put in close reading serves to emphasize the importance of really good illumination. The lighting of libraries certainly deserves special study. Any one who has passed much of his time in reading under these conditions must have been struck by the fact that the lighting is rarely all that it should be. The illumination of the reading-tables may be defective, owing to improper location of lights and other causes. Lights are also frequently placed so as to offend the eye of the reader as he glances up from his book, or so as to get into his line of vision as he is looking for a book on the shelves.

I should like to point out, too, that this is emphatically a case in which cheeseparing economy in the matter of lighting is out of place. It is manifestly absurd to spend large sums of money on books and buildings and then to grudge the small additional expenditure necessary to enable both to be put to the purpose for which they were

intended. Naturally it is only by means of the *illumination* we produce that we are able to use either.

The same considerations apply, as I have previously pointed out, to factory lighting The output and character of the work turned out in a factory depends very largely on the comfort of the workers, and it is false economy indeed to grudge the cost of the necessary illumination -- an expense which is usually a mere fraction of the money spent on tools and skilled labour. My remarks on the desirability of testing the illumination of school buildings are at least equally applicable to factories. Children are still employed in factories at a comparatively early age, and it is recognized that a carefully organized system of inspection is desirable in order to secure their physical well-being. The point to which I wish to draw attention is as follows. Why should it be considered necessary to test the conditions of ventilation, the water supply, and the general sanitary conditions, and yet to pay no attention to the method of lighting employed ? Surely it must be evident that the strain of working by means of defective illumination may lead to equally serious consequences ! Here again I may venture to suggest that the existing system of inspection should be extended so as to include the illumination of factories. Very excellent machinery for this purpose is already in existence. Why not utilize it for the purpose of gathering data which, in addition to improving the conditions of work of employees, might be very beneficial in furnishing data from which to draw conclusions as to existing defects in illumination and the means of remedying them.

I feel that the importance of the matter justifies the appointment of a special commission, consisting of a fully representative collection of impartial and accredited experts to deal with the whole question of lighting schools, libraries, &c. We have had many commissions in the past, created for the purpose of studying matters of relatively lesser importance to the nation as a whole.

Finally, I should like to say something upon the subject of street lighting—a problem of exceedingly great interest to municipal authorities. Here there is still ample room for improvement.

It must be recognized that the illumination in many cases is only too frequently very far from what the situation demands. The illumination of the streets of a district, for instance, has hitherto been in the hands of the local engineer, who is responsible for so many different matters that often he has hardly the opportunity to make himself as efficient as is rendered desirable by the introduction of new illuminants and the recent strides that have been made in modern methods of lighting.

Even granted, however, that the engineer is a man who is really impressed with the need for better illumination, and has gone out of his way to study the intricacies of the subject, he is often allowed but a small measure of freedom in carrying out his ideas, and is subjected to hindrance, which is attributed to outside circumstances by which the street-lighting committee of the district are influenced.

One cannot but be struck by the fact that although so much money is expended annually in the lighting of streets, there are no adequate tests and specifications in general use which would enable the authorities to at once determine whether the illumination in a street is up to the prescribed value or no.

I, of course, realize that the problem appears to be a complicated one, and that many different issues are involved. No doubt, for instance, the conditions to be prescribed in the case of streets differing in character, streets lined with shops, busy thoroughfares, and side streets, &c., differ considerably. But I feel confident that a full inquiry into the subject by a commission of experts representing the various systems of illumination involved would lead to very valuable results, and might, at least, enable us to decide upon some definite working basis on which the illumination in our streets is to be measured. I also feel that

there is a great need for greater co-operation between those responsible for the lighting of adjacent districts. Only the other day I had the privilege of conducting a visitor from the United States, who was interested in street lighting, on a circular tour lying well within the five-mile radius. He was amazed to find that no less than twelve distinct methods of illumination were in evidence.

Another matter on which co-operation is desirable is the making of frequent tests on new systems of illumination. The perpetual experiments in adjacent districts which are continually taking place not infrequently lead to a considerable waste of energy and money. On the other hand, it must be recognized that it is hopeless to place reliance on data obtained only a few years ago. The conditions are constantly changing. New illuminants and new methods of utilizing them to the best advantage are constantly making their appearance.

Bearing these facts in mind, I wish to amplify a suggestion which I made two years ago in an article on 'The Need for the Illuminating Engineer' (April, 1906). I mean the establishment of a joint municipal testing laboratory, a permanent home of experiment in illumination, conducted on strictly impartial lines, and on a sufficiently large scale to enable practical conditions to be genuinely reproducible. Consider the advantage to municipal bodies of having an accredited testing laboratory of this description, in which experiments on a sufficiently extensive scale could be carried out by a recognized experts, at their disposal. The results of such experiments might be utilized by all the authorities participating, and the requisite annual contribution of each body to the total expenses would certainly be trifling in comparison with the saving effected. Moreover the series of experiments undertaken at the laboratory would be always carried out by the same experts, under known and specified conditions, and this is certainly no small advantage. In such an establishment a collection of all the most recent illuminants and the most recent methods and instruments for testing illumination should find a place. Of recent years, since the practical importance of testing illumination has come to be fully realized, great strides have been made in the measurement of light and illumination. It is becoming increasingly difficult for any one to keep pace with the most recent developments, and an easily accessible building, where all the newest instruments would be on show, would be of very great value to manufacturers and engineers, and municipal councillors interested.

I have dealt with all these points in some detail because of their great importance, both from the standpoint of municipal authorities with whom rests the responsibility of providing the illumination in our streets and public buildings, and also from the point of view of the public for whose benefit such illumination is intended. I know that those who undertake such responsibilities are frequently busy men, who can ill spare the time that they devote to the public service, and cannot fairly be expected to be experts in the subject of illumination themselves.

Good and efficient illumination is as essential to the welfare of the general public as good ventilation, good food, or good drainage, and ought to receive the same consideration that is bestowed on these quantities.

The Measurement of Light and Illumination.

By J. S. Dow.

(Lecture delivered at the Municipal Building and Public Health Exhibition, May 11th, 1908.)

In his lecture last Wednesday Mr. Gaster dealt with the importance of illumination and the measurement thereof, both to the municipal authorities — who are responsible for the lighting of our streets and public buildings—and to the general public for whose benefit this illumination is intended.

The possibility of studying illumination in the manner referred to depends primarily upon our ability actually to test and measure our illuminants, and to estimate the effect they produce in a commericial way. In my lecture to-night I shall try to describe briefly some of the recent developments in the subject of light-measurement. Naturally, in the time at my disposal, I can only hope to touch in a general fashion upon a few of the most important aspects of the subject, and I must ask your indulgence if I occasionally pass over points on which you may wish to hear fuller details, or dwell upon others with which some of you feel yourselves sufficiently familiar.

In the first place, I should like to point out how great is the alteration in the general outlook on the subject of photometry compared with what it was a few years ago. Only a few years ago the whole question of light-measurement was regarded as an interesting scientific study; but the vital practical bearing of the matter was hardly generally realized. There were, indeed, a few pioneering workers in the subject, the benefit of whose efforts we reap to-day; but such researches as were carried out in this country were almost invariably purely scientific in their scope and aim.

This indifference may be partly explained by the fact that our available illuminants were then few in number.

Possibly those of you who have not followed this matter closely will hardly realize the extraordinary progress—and more, the extraordinary increase in our rate of progress—that is now taking place in our ideas. Mr. Swinburne, in his Presidential Address to the Institution of Electrical Engineers in 1902, summed up the situation as follows :—

"Our chief work, until lately, has been producing light. Here the inefficiency and waste is prodigious, and though it is mostly unavoidable, there is still great room for improvement. We take great care over our stations, watching every penny from the coal shovel or mechanical stoker to the station meter. We quarrel over 1 per cent. in the generators. When we get to the mains we care less, and once we get to the consumers' meters we care nothing at all."

Since the date of Mr. Swinburne's address we have seen a wonderful development in illuminants. We have seen great progress in flame-arcs, the metallic filament glow-lamps, the inverted gas mantle, and the development of high-pressure gas-lighting and petrol-air lighting, not to mention the mercury arc-lamp, the Moore vapour tube, and many other lamps which are still not very generally familiar to the general public. Naturally this progress has had the effect of drawing attention to the necessity for studying the best methods of *using* light.

After all, what the consumer wants is illumination, *i.e.*, light usefully applied. Therefore, we must have means of ascertaining, firstly, whether a source of light is really giving the light it is supposed to do, and, secondly, whether, having obtained the light, we are distributing it to the best advantage. Let us therefore now pass to the main subject of my lecture, and consider exactly what is wanted in order to describe the "power of creating brightness"—the illuminating power of a light.

It will be evident in the first place that we cannot, at least at the present time, readily expect to measure this quantity *directly* by the movement of a pointer or by any mechanical means, as in the case of electricity, for instance. We must, in fact, necessarily form our conclusions as to what lights can do by comparing their capability to make a surface *bright*. With this object in view we say that if we place either of two lights at a given distance from a white screen, and if, under exactly the same conditions, they both cause this surface to appear equally bright, the two lights have the same illuminating power. Given two sources of unequal intensity we can then adjust their distances from the screen so as to secure this condition, and calculate their relative effects by noting their relative distance. Or we can alter *the angle* at which the rays from one of the sources strike the surface. There are, of course, other methods of adjusting the illumination from two lights to equal brilliancy, according to some known relation; but into these I will not enter at present.

Our chief need, therefore, is some means of telling accurately when two portions of an illuminated surface, or two exactly similar surfaces, are equally illuminated. One of the very first methods and devices for this purpose was that of Count Rumford, who erected a rod in front of the white surface and judged the relative brightness of the two shadows. A modification of this device is used by the gas referees to-day, and the method has, indeed, certain signal advantages. Afterwards the plan suggested itself of placing the two sources of light on either side of a sheet of white paper and comparing the appearance of the two sides. The judgment in this case was rendered more accurate by the use of a "grease spot" on the paper, and this type of photometer, too, while very simple in construction, is still regarded as an excellent one at the present time. A modification of this instrument was effected in the Lummer-Brodhun photometer by means of an ingenious optical device. There have, of course, been many other types of photometers perfected, some of them exceedingly sensitive. An interesting instrument of recent date is a form of "contrast" photometer due to Dr. Bechstein, an example of which, by the kindness of the makers, Messrs. Franz, Schmidt & Haensch, I am able to show this evening.

To sum up, it may be said that we have to-day many very perfect instruments which enable this proceeding of judging the brightness of two surfaces to be accomplished with as great an accuracy as is commercially desirable—for lights of the same colour. A practised worker in photometry, for instance, would probably consider himself able to form a judgment of equality of brightness under these conditions to within $\frac{1}{2}$ per cent., while Dr. Clayton Sharp has recently estimated the total accuracy of general photometrical testing at about 2 per cent, which is certainly ample accuracy for practical purposes.

An additional question that has commanded the attention of those engaged in photometry of late years has been the introduction of sources of light, such as the incandescent mantle, the flame arc, and the mercury vapour lamp, which differ considerably in colour. Naturally it is very much more difficult to tell when two surfaces illuminated by such diversely coloured lights are equally bright. To meet this difficulty a new form of photometer, in which the two surfaces are exposed to the eye in rapid succession, has been devised. Most of you, in going home in the trams or tubes by night, have experienced the unpleasant flickering effect on the eye which arises

through the light from brilliant sources streaming into the tram or train as you pass by, and then being replaced by darkness. Just in the same way a throbbing, flickering sensation is caused when the two surfaces in the photometer, exhibited to the eye in succession as described, are unequally illuminated. But when we reach a point at which the apparent brightness of the surfaces is the same the effect ceases. On the slide which I now throw upon the screen you will notice a few of the devices which have been constructed for this purpose by Rood, Whitman, Krüss, Simmance and Abady, and others. A modification of the Rood method is exemplified in the Bechstein photometer, an example of which has likewise been kindly loaned to *The Illuminating Engineer* for demonstration purposes, and which I have again the privilege of showing to-night. Though primarily intended to facilitate the comparison of lights of different colour, flicker instruments can, of course, also be utilized for lights of the same colour, and a high degree of accuracy may be reached by such means. Before leaving this subject I must mention the simple and ingenious form of flicker-photometer due to Mr. Wild, who merely rotates a disc, half of which is greased and half plain.

You will see, therefore, that there are a number of excellent photometers available to-day. As far as the mere judgment of illuminated surfaces goes, we can carry out photometric operations with an accuracy well within practical requirements. At the same time, there is no reason why we should not reach still more excellent results in the future, and, indeed, ultimately render judgment of the equality of brightness of two surfaces as certain an operation as observing the position of a pointer on a scale.

Let us now turn to another most important matter in photometry. We cannot be content with merely comparing the brightness of two lamps which we happen to have by us. We want some standard of reference to which all such lamps can be referred. We want to be able to express the illuminating power of any lamp in terms of such a standard. This need was early realized, and it was proposed that the light from a candle, "1 candle-power," should be adopted as this standard. It was, however, soon realized that different candles, even burning under apparently the same conditions, gave very different results. Ultimately the whole question was considered of such importance that a Royal Commission was appointed and reported very unfavourably on the value of the candle as a standard. One interesting point, which illustrates the indifference that had seemingly been previously displayed to the illuminating powers of sources of light, was that according to the statement of certain witnesses, though great attention was paid to the conditions affecting general durability and reliability of candles, no tests of their illuminating power appeared to have been previously carried out or even contemplated.

Since the date of that Commission various suggestions have been made as to possible standards of light. A number of standard lamps have been developed in England, France, Germany, and the United States, some of which are shown upon the slides kindly lent for the occasion by Mr. Patterson, of the National Physical Laboratory, which I now throw upon the screen. While speaking on this point I must mention the incalculable benefit to the subject of light-measurement which has followed the efforts towards co-operation on the part of different countries. Appointed laboratories in this and the other countries mentioned are in constant communication; standardized glow-lamps are now exchanged and tested by the various laboratories in order that the standard of light in each country may be retained constant, and the ratios between the units adopted by different countries are now accurately known. It is now impossible for any serious misunderstanding as to the value of these standards to occur. One by one the small discrepancies still existing are being removed. One result much to be desired, which we hope to see achieved very shortly, is the establishment of an international unit of candle-power.

I may next mention one point which, though seemingly evident, has been the subject of considerable misunderstanding in the past. Naturally the light from any source of light differs very greatly in different directions. A glow-lamp, for instance, gives its highest candle-power in a direction at right angles to the filament, and its lowest in the direction of the cap of the bulb. An inverted mantle similarly gives its highest value immediately beneath the lamp and its lowest in an upward direction, where the burner obstructs the light. Strictly, therefore, in order to compare different sources, we ought to take into account *all* the light from a source in all directions. We may accomplish this somewhat laboriously by studying the distribution-curve of light from the source. A distribution-curve of this nature is naturally of considerable use in other respects. But the process referred to is greatly simplified by the arrangements which have recently been introduced in order to concentrate the net effect of all the light on the photometer.

The Matthews "integrating photometer," and the Ulbricht "globe photometer" exhibited in the slides which I will now describe, are examples of such devices. The important point to which I wish to draw attention, however, is that the possibility of uncertainty in this respect is now generally realized and guarded against in photometry.

Hitherto I have referred to the measurement of the light from the *source* employed, without reference to the conditions under which it is afterwards used. Naturally it is important that all such sources should be tested, for we want in the first place a guarantee that the lamp is capable of producing certain results. But, even if our sources of light are all that is desired, we may fail to *illuminate* our premises because we fail to use our lights correctly. If, for instance, we place our lamps in such a position as not to throw light where it is wanted, or if we lose all their light by surrounding them with absurdly dense shades, our illumination must suffer. Again, the light needed for any building depends very greatly upon the general scheme of decoration—upon the colour of wall-papers, for instance.

All this suggests the desirability of having some method of testing the actual illumination at the place where it is needed, and many types of portable photometers have been developed of recent years specially to meet this necessity. In such instruments the comparison source of light is placed, with the photometer, in one piece of apparatus. This source may take the form of a small oil-lamp, and small electric lamps are found very convenient; their use has been considerably simplified by the introduction of the osram and other metallic filaments.

Such an instrument can be carried about to any desired locality. It may be used to test the illumination in the street or at a table in a building. The construction of the "illuminometer," as this type of photometer is called, has been taken up with great energy during recent years, and there already exists a number of thoroughly practical instruments of this nature. Nevertheless there is every reason to suppose that much progress will be made in their manufacture in the near future, and that such defects as yet exist will be removed very shortly. I now propose to show some slides, exhibiting, among others, the instruments due to Mr. Trotter and Mr. Harrison in this country, Dr. Clayton Sharp and Mr. P. S. Millar in the United States, and Dr. Martens in Germany. Naturally these are only a few among the many existing instruments, but they will serve to show that really serviceable and practical results have been already achieved. I have also two other very interesting and simple forms of instruments on the table, that of Dr. Thorner intended for the purpose of testing whether the daylight-illumination in a room is adequate, and the "Simplex" photometer kindly sent from the United States by the inventor, Dr. C. H. Williams.

In conclusion, therefore, I wish to again emphasize my statements at the commencement of this lecture, as to the feasibility of measuring both

the illuminating power of a source and the actual illumination in practical conditions. Illuminometers are so simple in operation that, even in the hands of a novice, they may furnish an indication whether the illumination enjoyed by the consumer is adequate or otherwise. I think, however, that it must be realized that, in order to determine exact values, and to suggest a remedy for the defective conditions thus brought to light, the services of an expert in illumination are required. Therefore when, as Mr. Gaster suggests, illumination in streets and public buildings is subjected to careful specification and constantly tested by actual measurement, we may expect that such measurements will be conducted under the direction of an expert in illumination, who will be a municipal inspector, and will discharge duties every whit as essential as those undertaken by sanitary engineers and other municipal engineers of the present day. I look forward to the time when illumination will be specified and measured in the exact and precise manner that is now considered essential in the case of other commodities, such as food, water, and air, in which the general public is vitally interested, and it will be considered as reprehensible for the illumination of a street, public building, or conveyance to be manifestly deficient and below that legally enacted as for a tradesman to sell short weight or adulterated foods.

And, lastly, I wish to emphasize the importance of co-operation both on the part of those in the same country, but representing different systems and aspects of illumination, and on the part of different nationalities. The time has now come when it must be realized that there are many questions which affect the general public very closely which cannot be adequately settled by individual effort, while even questions of purely scientific interest often suffer through lack of suitable co-operation of workers in the same field, and their consequent ignorance of what is being done in other quarters.

In particular I should like to draw attention to Mr. Gaster's proposal, now two years old, that a permanent home of experiment in matters of illumination, including a museum where the ever-increasing collection of recent instruments for photometry and the measurement of illumination could be gathered together and rendered accessible to those generally interested.

It is a platitude in these days to remark upon the growing internationalism of science, but the work of the International Photometrical Commission and the concerted effort between the laboratories of the nations interested is an excellent example of what is possible by this means. In reality all the nations have contributed their share in assisting the progress of the movement towards better illumination. The United States, in establishing an Illuminating Engineering Society, have proved their appreciation of the need for mutual assistance in this matter; we ourselves have now a journal devoted solely to illumination, regarded from an impartial and international standpoint, and we have also every reason to be proud of the work of the many pioneers in the subject in this country, such as Sir Wm. Preece, Mr. Trotter, Mr. Dibdin, Mr. Vernon Harcourt, Sir Wm. Abney, to mention only a few of the names that occur in this connexion. To these early efforts the apparently sudden growth of interest in the subject of illumination is largely due. One may, indeed, sum up the situation in the memorable lines :—

For while the tired waves, vainly beating,
Seem but a painful inch to gain,
Far back, by creeks and inlets making,
Comes, silent, flooding in, the main.
And not by eastern windows only,
When daylight dawns, comes in the light.
In front the sun climbs slow, how slowly!
But westward look! the land is bright!

Some Recent Photometers and Illuminometers.

THE instruments exhibited at the Municipal Exhibition may be classified as photometers and illuminometers respectively, *i.e.*, instruments intended for the measurement of the light-giving capacity of sources and instruments for the measurement of illumination. Attention may first be concentrated on the various photometers exhibited at the exhibition. Nearly all the photometers in practical use at the present day may be included in the divisions of "equality of brightness," "contrast," and "flicker" photometers, and examples of all these three classes were shown.

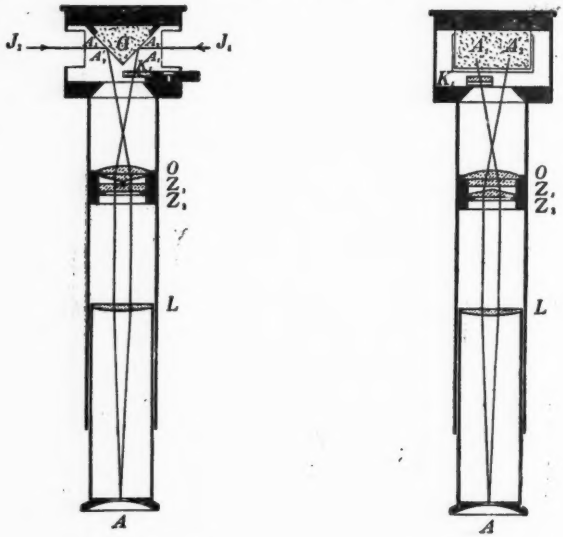


FIG. 1. FIG. 2.

THE BECHSTEIN PHOTOMETER.

In Figs. 1 and 2 is shown a recent type of Bechstein instrument, which can be used either as a contrast photometer or on the equality of brightness principle.

The plaster of Paris prism G is illuminated by the rays from the two sources J_1 and J_2, to be tested. The rays from the illuminated photometrical surfaces then traverse first the lens O, then the two biprisms Z_1 and Z_2, and finally the lens L on their way to the eye of the observer at A. The dividing lines of the prisms Z_1 and Z_2 are perpendicular to one another. Thus in the diagram the edge of the prism Z_1 is visible in Fig. 1 and the edge of the prism Z_2 is not, while in Fig. 2 the reverse is the case. The angles of the prisms are so adjusted that the prism with its dividing edge vertical, Z_1, divides the field of view into two equal portions, the left region being illuminated by rays from the left side of the ritchie wedge G, and the right region in the same manner by rays from the right side. The second prism Z_2 exerts a similar action, its dividing edge being, however, horizontal. As a result the field of view is divided into four quadrants which appear equally bright when the photometer

is in balance as an "equality of brightness" photometer.

The contrast element may, however, be introduced by merely inserting two thin squares of glass K_1K_2 in the path of the rays illuminating two opposite quadrants, as shown in Fig. 3. A small percentage of light is absorbed in this way. Fig. 4a indicates the appearance the field of view will now assume the photometer is in balance, and Figs. 4b and 4c show its appearance when slightly disturbed from this position in either direction.



FIG. 4a.



FIG. 4b.



FIG. 4c.

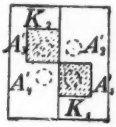


FIG. 3.

BECHSTEIN CONTRAST PHOTOMETER.

Many different forms of flicker photometers are now available. Two of the most recent types, those due to Dr. Bechstein and Mr. Wild respectively, were shown at the exhibition. The earliest flicker photometers may be divided into two classes, those in which the photometrical surfaces themselves were moved, as occurred in the Whitman sector photometer, and those in which a lens or prism was oscillated in front of the dividing lines between the illuminated surfaces in the photometer, as in the instrument devised by Prof. O. Rood.

The Bechstein flicker photometer utilizes a modification of the Rood device. The optical arrangements are shown diagrammatically in Fig. 5. The two sides of the wedge G are illuminated by means of the two sources to be compared, J_1 and J_2. The path of the rays from the photometric surfaces to the eye is then as follows: The rays pass through the lens L_1, then through the prismatic arrangement Kk to the eye-piece lens L_2, and ultimately to the eye at A. The prismatic arrangement Kk consists of a prismatic annulus K, the angle of which is so chosen that in the position shown only the rays from the right side of the wedge are brought to the eye-piece. Within the annulus K is fixed the disc k, which is likewise prismatic, having an angle of inclination equal to, but in the reverse direction to that of the annulus. Consequently only the rays from the *left* side of the prism passing through this disc are brought to the eyepiece. The result is that the eye sees a field of view similar to that shown in Fig. 6a, the centre of the circle being illuminated only by rays from the left hand source and the outer ring only by

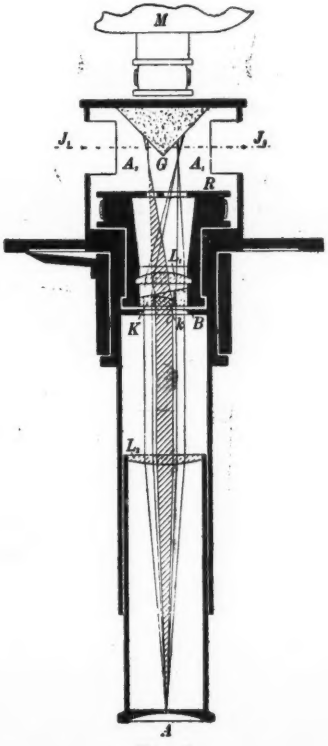


FIG. 5.

BECHSTEIN FLICKER PHOTOMETER.

means of rays from the right-hand source.

If the prismatic arrangement Kk is kept stationary we can employ the photometer on the "equality of brightness" principle, and obtain balance by judging when ring and centre appear equally illuminated.

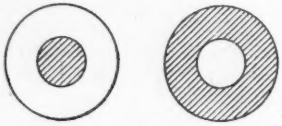


FIG. 6a. FIG. 6b.

FIELD OF VIEW, BECHSTEIN FLICKER PHOTOMETER.

In order to obtain the flicker the prismatic disc Kk is rotated about a horizontal axis by means of a band from a small motor passing over the pulley R. It will now be observed that, when the disc has rotated through 180 degrees, the rays of light which formerly illuminated the centre now illuminated the ring, and vice versa; the field of view is therefore now that shown in Fig. 6b. Hence when the disc is rotated at a suitable speed, *both* ring and centre will appear alternately dark and bright, and a flicker will be seen which only disappears when centre and ring are equally bright.

A very simple modification of the Whitman method is due to Mr. Wild, who merely rotates a paper disc, half of which is greased and half plain, as shown in Fig. 8, illuminated on each side by the two sources of light to be tested in the ordinary way. The observer looking down a telescope sees,

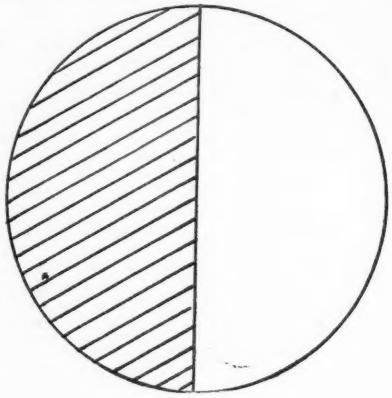


FIG. 8.

in rapid succession, first the greased and then the plain portion reflected in the inclined mirror M, as shown in Fig. 9. The photometer is thus extremely simple in construction, and it is said that very great sensitiveness

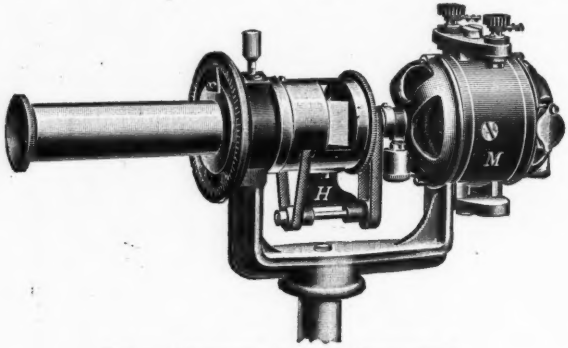


FIG. 7.—BECHSTEIN FLICKER PHOTOMETER.

In the model shown in Fig. 7 the motor is arranged in such a way that the whole instrument can be easily reversed without the observer being required to change his position at the bench.

can be obtained when a suitable grease-spot screen is employed. Another advantage claimed for the instrument is that the rays from the two sources of light to be tested strike the surfaces of the disc vertically,

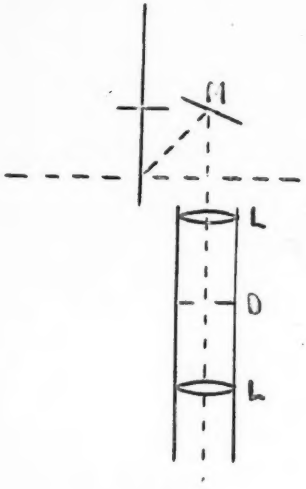


FIG. 9.
DIAGRAM OF WILD FLICKER PHOTOMETER.

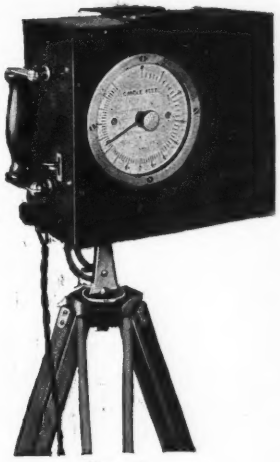


FIG. 11.
TROTTER UNIVERSAL PHOTOMETER.

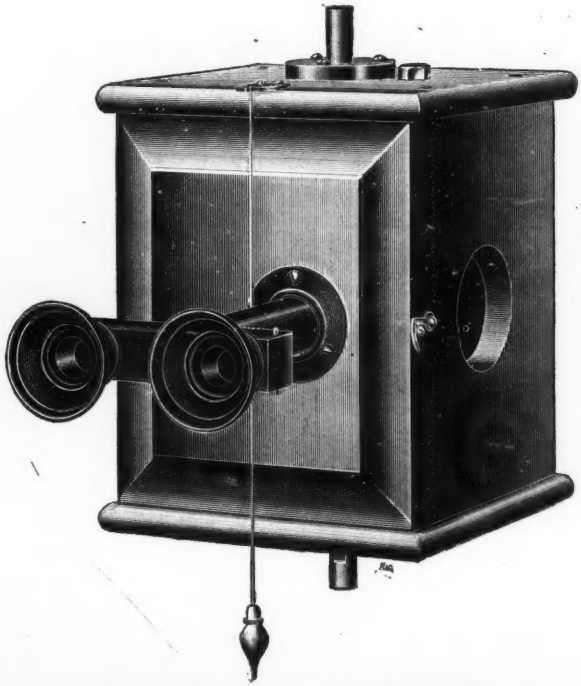


FIG. 10.—THE WILD FLICKER PHOTOMETER.

as is the case with most photometers of the equality of brightness or contrast photometers, and that therefore the possibility of "angle-errors" is much reduced. Fig. 10 shows a general view of the most recent type.

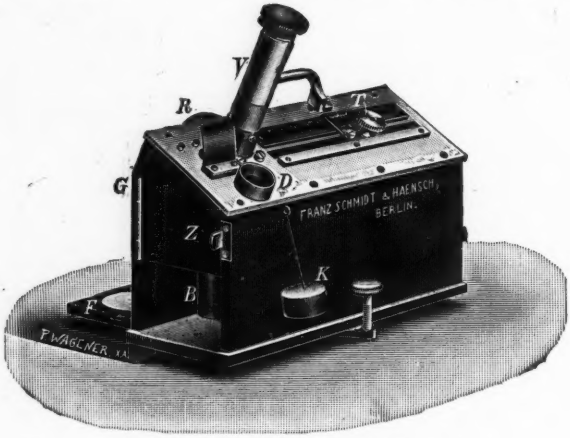


FIG. 13.—MARTEN'S ILLUMINOMETER.

Some description may now be given of the various instruments for the measurement of illumination exhibited. The Trotter Universal Photometer is shown in Figs. 11 and 12. The comparison-source of light is in this case a small glow-lamp L, the rays of light emitted by which strike the mirror M, and are thus reflected on to the white diffusing screen S_1, receiving the illumination it is desired to measure. The observer looks at the white diffusing screen S_2; in this is cut a small aperture with very sharp edges. The observer is thus able to compare the brightness of the actual illumination of the surface S_2 with that of the screen S_1. The latter can

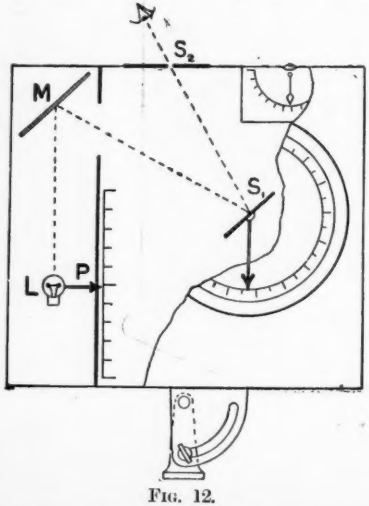


FIG. 12.
TROTTER UNIVERSAL PHOTOMETER.

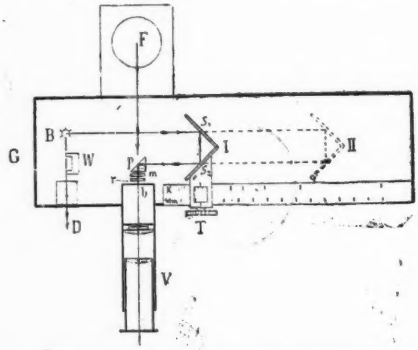


FIG. 14.—MARTEN'S ILLUMINOMETER.

be rotated so that the light strikes it at various inclinations, and the illumination is thus altered through a definite and convenient range from zero to 2 candle-feet. The actual value in candle-feet is obtained by observation

of a pointer attached to the screen S_1, moving on a scale on the outside of the box containing the photometer, as shown in the diagram.

The small glow-lamp is carefully aged and standardized, and, in addition, is run at such an efficiency as to give a light intermediate in colour between

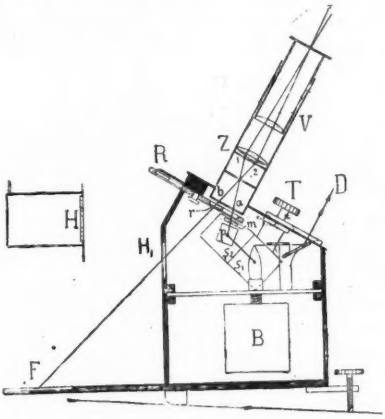


FIG. 15.—MARTEN'S ILLUMINOMETER.

that of an underrun glow-lamp and the whiter light of the arc. As a result no very serious difficulty is experienced by a practised operator in using the instrument with the range of colour occurring in the case of the ordinary illuminants in use for street lighting. In order to facilitate the comparison of such sources, however, a modification to the conditions suggested by Crova is obtained by using yellow screens of varying depth of colour, the percentage of light absorbed by which has been previously ascertained. If, for instance, the light striking S_2 is yellower in character than that striking S_1, S_1 may be slightly yellower than S_2, so that the two screens appear very nearly the same colour. After making the measurement we should then allow for the fact that the coefficient of reflection of the yellower screen S_1 is less than S_2, the necessary correction being marked on the screen used.

In order to use the small glow-lamp no more than is actually necessary, and thus at once to reduce the gradual fall in candle-power of the lamp with use to a minimum, and to economize the use of the small accumulator supplying current to it, a small spring-key is provided; by this means the lamp is lighted just as long as may be necessary in order to get a reading. Owing to the small length of time for which the lamp is in use its candle-power only varies very gradually. However, the possibility of such a change, or of the pressure of the battery falling below the correct value of 4 volts, is provided for by means of the scale at P, which enables the lamp to be brought nearer or further from the screen S.

The general working of the Martens illuminometer will be understood from Fig. 13, which shows a general view of the instrument, and Figs. 14 and 15, which represent a sectional plan and elevation.

The plaster of paris surface F receives the general illumination the intensity of which it is desired to measure. The rays from this surface pass into the telescope of the instrument at *b*: its brightness is compared with that of the frosted glass *m*, illuminated by the small benzine lamp B, the rays from which enter at *a*. The flame-height of this lamp is regulated to exactly 20 mm., this height being controlled by observations through the window at D. The rays from the benzine lamp, before proceeding to illuminate the plate *m*, must suffer reflection from the pair of mirrors S_1, S_2, as shown in Fig. 14. By moving these mirrors to and fro by means of a rack and pinion arrangement we can weaken or strengthen the brightness of the illuminated plate *m*, and can determine the relative values of the intensity of illumination, corresponding to equality of brightness in the field of view, by means of a scale calibrated direct in lux.

This alone, however, would only enable the comparatively small range of illumination of 15 to 1 to be measured, and therefore a disc *r* is inserted in front of the plate *m*. This disc contains a series of graduated smoked glasses, the densities of which are such that the illumination read upon the scale must be multiplied by 0·01, 0·1, 1, 10, and 100 respectively. Special provision is made for the measurement

of the intensity of unknown sources by means of the cap shown in the diagram containing the diffusing semi-transparent screen H. This cap can be fitted on in front of the aperture H_1.

Another accessory, specially intended to facilitate the comparison of lights differing in colour, is the introduction of a pair of red and green glasses, either of which may be inserted in the eyepiece of the telescope. The observer then takes a reading, firstly, looking through the red glass, and, secondly, through the green glass.

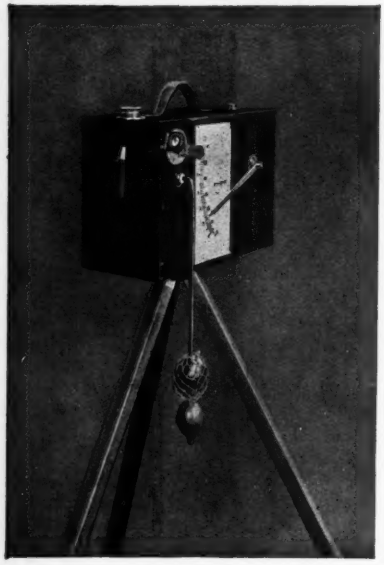


FIG. 16.
HARRISON STREET PHOTOMETER.

The mean of these two results is then assumed to be a measure of the relative total intensities of the two illuminations compared.

In Figs. 16 and 17 will be seen the general arrangement of the Harrison street photometer. The standard of light is again a small glow-lamp L, which receives current from a small accumulator within the instrument, and which illuminates the moveable screen S_1. S_2 represents a white sector-disc (*i.e.*, a disc from which two symmetrical sectors are cut out) which is driven by means of a small air-blast at any desired speed; on this screen is received the illumination which it is desired to measure.

The eye of the observer at E sees, in rapid succession, first the illuminated white surface of the sector S_2, and then, in the mirror M, the illuminated surface of the screen S_1. All that is necessary, therefore, is to alter the inclination of the screen S_1 until no flicker can be perceived by the eye. The surfaces S_1 and S_2 then appear equally bright. The actual illumination at the screen S_2 can be read off by the reading of a pointer attached to S_1, and moving on a scale graduated in candle-feet. In the position shown in the diagram the photometer is arranged to measure the intensity at an angle of 45 degrees to the vertical, but, by tilting the photometer, the intensity at any measured angle may also be obtained.

The method of producing the air blast, by the action of which the rotating

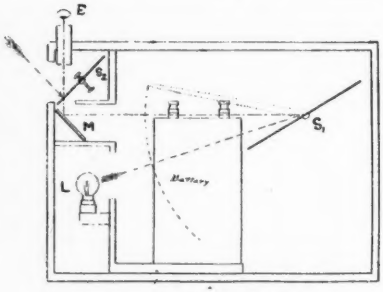


FIG. 17.—HARRISON PHOTOMETER.

sector is driven, is shown in Fig. 17. The apparatus merely consists of a rubber tube terminating in two balls which are controlled with the hand. The upper one of these serves to maintain the requisite pressure, and retains the speed constant while a reading is taken, the lower one being pressed in the hand in such a way as to accelerate or retard the speed as may be required. The small glow-lamp in the photometer is put in circuit by inserting a plug-key into a socket on the outside of the instrument. When measurements are not actually being made, this plug is

removed and the connexion broken. In order to secure a wider range of measurement two alternative lamps of different candle-power are usually provided, either of which can be lighted at will by the insertion of the key into one of two distinct sockets. Illuminations up to 5 candle-feet can be determined.

The ingenious little apparatus shown in Figs. 18 and 19 is intended to enable a rough idea to be formed as to whether the daylight-illumination in a room is satisfactory or not. The instrument really compares the brightness of an image of the sky with the actual illumination to be examined. The enclosed box shown in Fig. 18 contains a sheet of paper *fg* with a fine aperture at *a*. Vertically above this fine aperture *a* is to be found a convex lens *d* and an inclined plane mirror *e*, which can be rotated about both a horizontal and a vertical axis. The aperture *a* is situated at the focal length of the lens *d*. A second paper surface at *c* receives the available intensity of illumination to be examined.

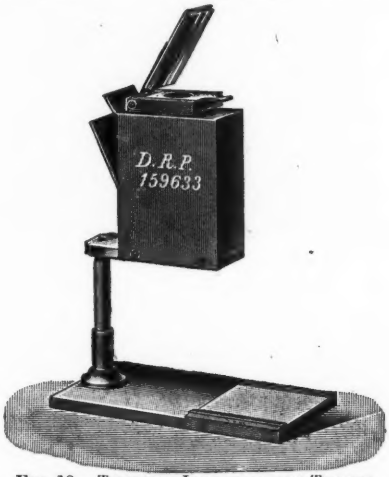


FIG. 18.—THORNER ILLUMINATION-TESTER.

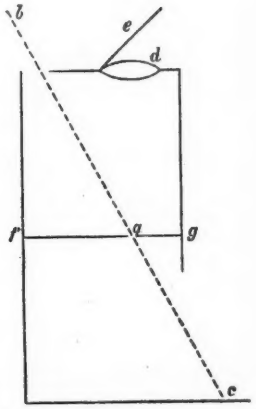


FIG. 19.

An observer, looking along the direction of the dotted line *bae*, sees the surface *fg* and this second surface through the aperture *a*. He then turns the mirror *e* in such a way that an image of a portion of the sky is formed on the region of the paper screen *fg*, adjacent to the aperture *a*. He now judges the value of the existing illumination by merely observing whether the surface illuminated at *c*, seen through the aperture, appears brighter than the image of the sky formed on *fg*, or vice versa. If it appears darker, as shown in Fig. 20a, we say that the illumination is too weak. If, on the other hand, the spot appears brighter, as in Fig. 20b, the illumination is judged to be sufficiently bright. Of course it may happen that *no* portion of the sky is visible from certain positions in a room. When this happens, however, we are safe in condemning the daylight-illumination in the room without further test.

As the standard brightness of the image of the sky is to some extent an arbitrary value, several stops are provided, which correspond to illuminations in the ratio 1, $\frac{1}{3}$, and 2. Determinations are best carried out in cloudy weather. Naturally precautions must be taken to avoid abnormal conditions. The effects of a heavy fall of snow, for instance, and the light reflected upwards as a result, would cause an abnormal distribution of illumination in the room tested. In the same way results obtained when the sun is streaming direct into the room will be too high,

while, in the case of a clear sky, the process of testing is somewhat affected by the fact that the image of the sky appears a different colour to the aperture.

Finally, mention must be made of

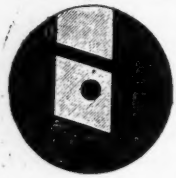


FIG. 20a.



FIG. 20b.

the Williams Simplex photometer. The photometer is stated to be mainly intended to measure the relative brightness of distant sources of light, such as railway or marine signal lights, &c.

The method employed is merely that



FIG. 21.—SIMPLEX PHOTOMETER.

of extinction, and consists in passing a specially prepared photographic film, increasing gradually in intensity from one end to the other, before the eye until the source of light becomes indistinguishable. As shown in Fig. 21



FIG. 22.—SIMPLEX PHOTOMETER.

it may be carried in the pocket. When in use the cap covering one end is removed and attached to the instrument in such a way as to screen the eye, which is applied to the small aperture which may be seen in Fig. 22. With the other hand the photographic film is then gradually removed from the instrument until the light is just cut off. Then, without moving the glass wedge, the instrument is removed from the eye, and the relative degree of obscurity of the film required to cause extinction inspected through the sight-hole, also shown in Fig. 22.

The numbers on the film correspond to stellar magnitudes, that is to say,

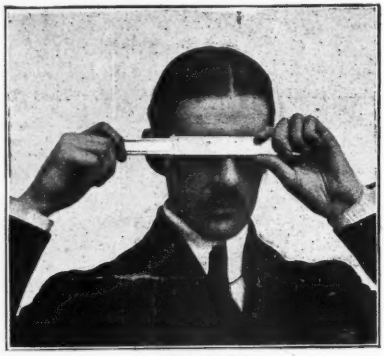


FIG. 23.

the relative values of the intensity increase in geometrical progression in a ratio of about 1 to 2·5, a difference of 5 magnitudes thus corresponding to a ratio of 1 to 100.

It must, of course, be understood that the readings are only intended to be *relative*. Thus the absolute brightness of the light depends upon the state of the atmosphere, while different people, whose eyes differ as regards sensibility to light, will naturally obtain different readings, though the *relative* results obtained by each person should be the same.

Light and Illumination at the Royal Institution.

THE great interest now felt in this subject is illustrated by several recent events of interest at the Royal Institution. Prof. Trouton, F.R.S., recently delivered two very interesting lectures on the theory of light, to which we mean to refer in detail in our next number.

At the Conversazione on Friday evening, May 22nd, *The Illuminating Engineer* was also invited to exhibit some of the instruments, described above, and previously shown at the Municipal Exhibition.

The exhibits, which included the Martens and Trotter illuminometers, the Bechstein contrast and flicker photometers, and the Thorner illumination-tester, proved to be of considerable interest to many of those present.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

The Physiological Basis of Illumination.

By Dr. Louis Bell.

(From the *Proceedings* of the American Academy of Arts and Sciences, September, 1907, Vol. XLIII. No. 4.)

(*Concluded from p.* 418.)

Finally, one is nowadays often confronted by questions of colour. Until electric lighting in its more recent forms appeared there was a sufficient similarity in the colours of artificial illuminants to place them substantially on a parity. At present, strong colours are common, and are likely to be increasingly so, since, as I have noted in a previous paper (*loc. cit.*), selective radiation is necessary to high luminous efficiency. One has to deal with the yellow of the flaming arc, the yellowish-green of the Welsbach, the blue-green of the mercury tube, and the violet of the enclosed arc, all of which may have to be compared with the deep orange of the Hefner lamp.

Practically the question of suitable colour resolves itself into two parts—first, the effect of colour on the proper functioning of the visual apparatus, and second, its relation to our observation of coloured objects. I shall not take up here the theories of colour vision, save to note that many of their difficulties may now be charged to the existence of at least two kinds of independent visual elements, the rods and cones, differently distributed in the retina, and possessing two radically different types of visual sensitiveness. That the cones are highly evolved rods has been shown beyond much doubt by Cajal, and is in evidence in the simple rod structure found in the parietal eyes of some fishes and lizards and in lower organisms generally. Whether, as Mrs. Franklin* surmised, there are definite intermediate phases of sensitiveness between the achromatic vision of the rods and the full chromatic vision of the cones, is an important topic for research.

May I venture to suggest that there are some reasons for thinking that there may even be a difference in kind between a simple photochemical rod stimulation and the strongly selective stimulation of the highly specialized cones? Selective activity does not necessarily connote chemical instability. They may coexist, as in some organic dye-stuffs, or may be entirely independent, as in the fluorescence of heavy paraffin oils. The presence of strong pigmentation at the rods and its absence at the cones, coupled with the absence of visual purple in some nocturnal creatures whose eyes are presumably specialized for very weak light, suggests that the evolution of the retinal elements may have proceeded along more than one line. In fact, the Young-Helmholtz and Hering doctrines may find in a heterogeneous retina a certain amount of common ground. Be this as it may, mankind certainly has superimposed a very sensitive but achromatic rod vision, and a much less sensitive but chromatic cone vision, the latter being mainly central and the former mainly peripheral. The passage from predominant rod vision to predominant cone vision is shown in the sharp flexure of the curves in Fig. 1. The exact point at which the colour sensitive cones begin to get into action undoubtedly varies greatly in different eyes, and in the same eye in different conditions of adaptation. As the illumination is progressively diminished, colour vision gets more and more imperfect and uncertain, especially toward the red end of the spectrum. The effect is shown very clearly in the variation of Fechner's fraction with colour as the intensity changes. Fig. 5 shows the change in $\frac{dI}{I}$ with λ for intensities of 15 meter-candles (*a*) and 0·75 meter-candles (*b*) respectively from the data obtained by König and Brodhun (*loc. cit.*). Looking at the latter, it is

* *Mind*, N.S., 2, 473 *et seq.*

evident that for the orange and red, vision must be very poor indeed, and in no part of the spectrum really good. In curve *a* colour vision is pretty well established, although there are still traces of the point of inflection, which, as we shall presently see, falls near the point of maximum sensitiveness in very weak light, as if the superimposed rod vision were still helping out at this moderate intensity.

The Purkinje phenomenon, now well known to depend on the progressive failure of cone vision, also gives valuable evidence along the same line. It was noticed more than twenty years ago by Prof. Stokes* that the phenomenon varied with the areas involved, and recently Dow* has found that for small areas (*i.e.*, nearly central and hence mainly pure cone vision) Purkinje's phenomenon appears only below about 0·2 meter-candle. This figure would quite certainly have been somewhat higher had he used instead of red and signal-green glass the primary red and green; but it is clear from his results that the superposition of rod vision has a very considerable effect at moderate illuminations.

Finally, one must consider the luminosity curves at various intensities. Fig. 6 gives in curve *a* the relative luminosities of the spectrum colours at fairly high intensity. The maximum is in the yellow, and the falling off, especially on the red side, is very rapid. This seems to be about the normal curve when the eye is fully in action. Curve *b* gives the luminosity curve for an intensity of about 0·0007 meter-candle. At this point colour sensation is practically extinguished, and the maximum luminosity is perceptible, in what would seem the pure green were the light brighter, very near the E line and at a point corresponding to the inflection in the curves of Fig. 5. This is practically the condition of pure rod vision. Curve *c*, Fig. 6, lends confirmatory evidence. It is the luminosity curve obtained by Abney* from a patient with pure monochromatic vision. He had apparently an absolute central scotoma (cones atrophied rather than replaced by rods ?), visual acuity greatly subnormal (central vision absent), and nyctalopia. This is a typical condition, nyctalopia being generally associated with central colour scotoma, leaving peripheral vision but slightly affected (Fick). The patient apparently had no colour perception, and his lumino-

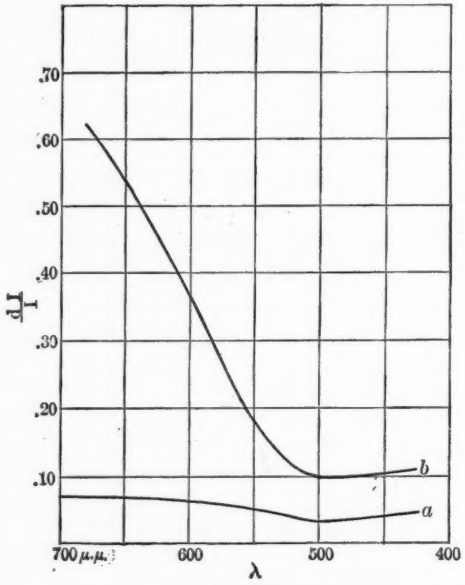


FIGURE 5

* *Nature*, 32, 537.
† *Phil. Mag.*, Aug., 1906.

* *Proc.* Roy. Soc., 66, 179.

sity curve was practically identical with *b*, the normal curve for very weak light.

It would be most interesting to get proper tests for luminosity in one of the rare cases of congenital hemeralopia which would present the reverse condition of rods inactive and cones nearly normal. A comparison of such a case with luminosity in the hemeralopia associated with *retinitis pigmentosa*, in which peripheral vision is progressively contracted, might give valuable evidence as to the existence of retinal elements intermediate in function between rods and cones.

To sum up this phase of the matter, rod vision seems to be predominant from the very threshold of illumination up to several tenths of a meter-candle, and to continue in force to all ordinary intensities, although rather easily exhausted.

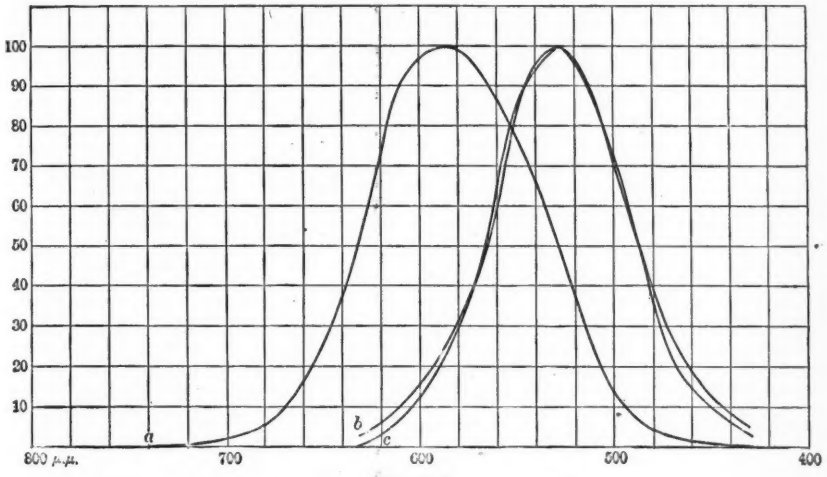


FIGURE 6.

It gives low visual acuity and shade-perception perhaps of the order of a tenth normal, but, such as it is, it is our main nocturnal reliance. Cone vision begins to come perceptibly into play at a few thousandths of a meter-candle, and at a few tenths is pretty well established, but does not become normal over the visual area below 5 or 10 meter-candles, and gains materially even beyond that, especially in acuity, which is weak at the lower intensities.

Acuity in practical degree is chiefly an attribute of cone vision. The general theory of optical resolution requires acuity inversely as the wave-length of the light concerned. In practice this difference is in great measure masked by other and larger causes of variation. Chief among these is the very low luminosity of the shorter wave-lengths on the one hand and of the very long ones on the other. For example, in comparing acuity at $\lambda = 500\ \mu\mu$ and $\lambda = 650\ \mu\mu$ there is a proportional difference really due to colour, but a ratio of 2·5 : 1 in luminosity in further favour of the green. Violet light favours acuity, if one can get enough of it, but a luminosity of ·02 of the maximum in the yellow stands in the way.

Certain strongly coloured lights, like the flaming calcium fluoride arc and the mercury arc, give apparently extremely sharp definition in black and white objects. In general this is not due to any advantage in colour as such, but to improvement in the conditions of chromatic aberration in the eye. At rest for distant vision, the normal eye is in focus for the rays of maximum luminosity, and the focus for blue lies perhaps 0·4 mm. in front of the retina. That is, the eye is short-sighted for short rays. In near vision the rear conjugate focus moves backwards and the eye finds focus on the blue with less accommodation than usual. Thus Dow* finds that, while the mercury arc gives easy and sharp definition for near vision, at a distance of twenty feet or even less it becomes difficult to get focus. Lord Rayleigh† noticed some years ago that in very weak light he became myopic and required a glass of —1 diopter to restore normal vision. This effect is of the order of magnitude required by the shift of maxi-

* *The Illuminating Engineer*, 2, 26 *et seq.*

† *Nature*, 31, 340.

mum luminosity into the green at very low intensities. Another phase of chromatic aberration is even more important. Were it not for the existence of a very high maximum in the luminosity curve, distinct vision would be impossible, since the difference of focus between the red and violet in the eye is something like 0·6 mm. and were these extreme colours highly luminous, there would be no focal surface to which the eye could adjust itself. Only the great predominance of the central colours in luminosity gives the chance for a fairly sharp image.

It is easy to show the difficulties into which equal luminosity throughout the spectrum would plunge us. If one forms a grid of certain purples by cutting strips of tissue paper of the required colour perhaps 5 mm. wide and 100 mm. long, and pasting them upon a dark neutral background spaced about their width apart, one readily finds the practical effect of chromatic aberration. From a distance of a couple of meters sharp definition of the grid is quite impossible. The purple chosen should give considerable absorption of the green, yellow, and orange, leaving strong red and blue evenly balanced in luminosity, and the background should be of not greatly different luminosity, so that the eye must rely mainly upon colour effects. The rays from the grid are then of two widely different colours, for which the focal length of the eye differs. There are therefore two image surfaces of about equal intensity, perhaps half a millimeter apart, and the effect is a curious blur, the eye hunting in vain for something definite upon which to focus.

Interposing now a deep red screen (concentrated saffronine is good), or a suitable blue screen, the image of the grid becomes nearly monochromatic, and appears sharply defined. This is an extreme case, but any monochromatic light has an advantage in definition if other conditions are at all favourable. It seems highly probable that the well-known trouble found at twilight in trying to work by a mixture of natural and artificial light is due to a similar cause. The predominant hue of diffused sky light is strongly blue, while that of gas flames, incandescent lamps, and like sources is strongly yellowish. At a certain point in the fading of daylight the luminosities of these widely different colours should balance closely enough to produce something of the effect just described, although the usual difference of direction in the two superimposed illuminations may play a part in the general unpleasant effect.

There is, however, an inherent danger in using monochromatic or strongly coloured light for general purposes. Whatever may be the nature of colour vision, a strongly coloured light utilizes only a part of the visual apparatus. If of high intensity to make up for inherently low luminosity, it rapidly exhausts that part, and produces, as is well known, a temporary colour blindness. There is, at least, a serious chance that long continued use of coloured light would produce persistent and perhaps permanent damage to colour perception. A light nearly white, with its maximum luminosity near the normal wave-length, runs the least chance of imposing abnormal strains on the visual apparatus.

In colour discrimination the same rule holds good, for any considerable departure from white leads to entirely false colour values. In closing, I may mention an interesting question which arises with reference to obtaining a light of high efficiency by building it up from the monochromatic primary components. Would the eye see clearly by such a light, and could it discriminate colours properly? The answer is probably, "yes." The equation for white is roughly

$$W = \cdot 20R + \cdot 30G + \cdot 50B.$$

These are quantities as determined by slit width in the spectrum or a like process. There is sufficient predominance of luminosity in the green to avoid trouble from chomatic aberration, and the actual working of the combination in giving photographs in natural colours is such as to indicate proper colour vision. As yet, however, no means are available for producing all three primary colours efficiently, and for white artificial light we are compelled to rely on what is in effect building up a nearly continuous spectrum from heterogeneous components, unless, as usual, we employ the continuous spectrum of an incandescent solid.

Electric Supply Prospects and Charges as Affected by Metallic Filament Lamps and Electric Heating.

By H. W. Handcock and A. H. Dykes, Members.

(Paper read before the Institution of Electrical Engineers, April 8th.)

(*Continued from p.* 429.)

DISCUSSION (Abstracted).

Mr. Arthur Wright remarked that the position of the industry as regards the new lamps needed careful consideration and handling. He thought, however, that the consumer ought to recognize that he was now in a position to use light more liberally than formerly. He could, in fact, have three times the light for the same power. He also hoped that the new lamps would enable the companies to reach many consumers at present not available. For this reason it was essential to do all that was possible to make things easy for the consumer, to avoid complexities, and to try to imitate the simplicity of the dealings of gas companies with the public. In the past the electrical industry had rather suffered through trying to provide for perfect safety at the cost of simplicity.

Increase of output was extremely valuable to the supply authorities. The high charges for house connexion were also a great drawback, and it seemed very desirable that engineers should turn their attention to the cheapening of this branch. At present it actually cost nearly as much per kilowatt to connect up as to build a power station.

Mr. Hugo Hirst mentioned that he had just handed in a paper to the Institution dealing with recent progress in metallic filament lamp manufacture; he thought that if the authors of the present paper had had an opportunity of studying this they would have modified some of their conclusions as to the effect of metallic lamps on the electrical industry.

He urged that there was a wide field for the extension of electrical supply. At present there was only about £6,000,000 invested in electrical works as compared with £27,000,000 invested in gas undertakings. Mr. Hirst also mentioned that he had recently proposed to fifteen central station engineers that they should combine to supply metallic filament lamps to the contractors, and thus be in a position to regulate their introduction.

Mr. W. R. Rawlings spoke from the contractor's view. He had no hesitation in condemning the maximum demand system, as regards its effect on the consumer. In fact he had never yet met a consumer who had thoroughly understood it. As a rule the consumer seemed to think that, in some mysterious way, the wiring was responsible for his high bills, and he sent for the contractor in consequence. What was wanted was greater simplicity.

In the same way consumers certainly would not be induced to use electric kettles and so on, if they found that this necessitated a separate meter. In Knightsbridge there were actually many triple systems of supply, involving three meters, three main-switches, &c., in the same house.

Mr. F. M. Long, of Norwich, explained the system of charging recently adopted by him. The present system consisted in merely charging 12 per cent. of the rateable value of a consumer per annum, and a uniform rate of 1*d.* per unit. Actually 10 per cent. of the rateable value would have served to enable the company to obtain the same revenue as previously, but the higher rate mentioned provided a margin. The system had worked excellently, and there had been no grievances or complaints. During the fifteen months for which it had been in use the number of customers supplied by the system had increased from 400 to over 800. The system also favoured the use of heating devices, and there had been about 100 radiators put in. In the case of business houses, &c., special terms were given, usually a charge

of £10 per K.W. required, and 1*d.* per unit. In the case of sign and advertisement lighting the initial charge might be reduced to £5. He also recommended that extra meters should be avoided as far as possible.

Mr. C. P. Sparks described the advent of the metallic filament lamp as the greatest thing that had happened for the benefit of the lighting industry for twenty years. The industry must ultimately benefit by their introduction, and in any case their adoption would come only gradually. The advent of the incandescent mantle had proved to have done the gas industry no harm. Yet the field was in this case much more fully covered than in the case of electricity.

He thought that the maximum demand system had proved to have grave disadvantages, in spite of its scientific nature, and felt that the industry rather owed Mr. Wright a grudge for being the inventor of it. Yet he had some doubts as to the practicability of the system adopted at Norwich. It might work very well in a small provincial town, but nevertheless prove unsatisfactory in the case of a big London company.

Mr. C. H. Stearn referred to the value of small local transformers utilized to reduce the P.D. at the consumers' terminals. When direct current-supply only was available it must be recognized that the present means of utilizing the metallic lamps were very imperfect. By using large units we obtained an undesirably great concentration of light. We could, of course, subdivide units by putting filaments in series, and the question arises whether it is best to do what is necessary in this way in a single big bulb, or to run a number of separate lamps in series. He favoured the latter plan, lamps so arranged being each provided with a compensating resistance which cut into circuit and replaced a filament in the case of a lamp failing. (The working of such an arrangement was exhibited by the speaker.)

Mr. P. Still thought that the system proposed by the authors entailed some difficulties, among which he might specify the really arbitrary nature of the fixing of the contract demand of the consumer. In this connexion an application form did not form a reliable guide. The consumer would very often modify his previously estimated demand, and introduce 16 candle-power lamps in the place of 8's, and so forth. The method would be of very much easier application to factories and business houses where, of course, different conditions prevailed.

Mr. L. Andrews maintained that the influence of the new lamps on the supply company's business must ultimately be good. He thought it was most essential that a system of charging should be adopted which the consumer could understand. A flat rate, though simple, was not equitable. A system introduced at Hastings which had been found to give very great satisfaction had been as follows. The consumer was charged 10*s.* per 8 c.-p. lamp put in (as determined by the maximum demand indicator) annually, and also 1½*d.* per unit.

Mr. S. F. C. Snell took an optimistic view of the situation. He considered that with the new lamps electricity was able to compete with the gas mantle, as soon as the cost per unit fell below 3½*d.* Many companies were now in a position to supply at this figure. Transformers were only to be regarded as a temporary makeshift.

Mr. Robert Hammond thought that it was unfortunate that the discussion had turned mainly upon tariffs. Now at last, thanks to the new lamps, electricity was again in a position to compete with gas on equal terms, and results abroad had often showed that electricity could displace gas for lighting purposes by their aid. He was not sanguine as to the possibility of the consumer being induced to raise his standard of illumination. In many cases the use of metallic lamps led to too much "glare" as it was.

Mr. Hammond endorsed what had been said as regards the inadvisability of installing separate meters in private houses to measure the power supplied to the lighting circuit and to electric kettles and the like. He considered the flat rate inequitable, and thought that Mr. Long's method of charging might be of great benefit in avoiding the unpleasantness accompanying the maximum demand system. To this end he hoped that the Board of Trade might be induced to allow the insertion of such provisions in the next electrical supply bill as would enable every company to make a fixed charge.

Mr. Leon Gaster congratulated the authors on their opportune paper. Many people seemed to think that the new lamps would merely result in more light being used, while there were others who feared that the consumer would now obtain the amount of light he desired at about a third of the energy previously taken. He himself thought that some compromise between these conditions was necessary; meantime

the gradual development of the lamps from high candle-power and low voltage to, ultimately, low candle-power and high voltage would enable supply companies to adjust their methods to meet the new conditions.

He was also glad to see that the point of view of the consumer was receiving attention, and thought that the chief necessity was to simplify the present system so that the consumer really understood the method on which he was charged. The plan suggested by the authors seemed a desirable compromise. Meantime he thought that, in cases in which the flat rate was offered as an alternative to the maximum demand system, a consumer who elected to be charged on the latter plan ought not to suffer as a result. He ought, therefore, to be assured that his bill could not come to more than that of his neighbour who paid a flat rate, but might come to less.

Mr. Gaster also advocated closer co-operation and mutual tolerance between gas and electricity supply companies. In particular he urged that an industry that employed such an immense capital as that invested in gas would not readily give way unless it was able to perceive possibilities of remunerative extension in other directions.

Mr. F. Gill agreed that the maximum demand system was productive of much misunderstanding. He felt that greater simplicity was needed, and urged the possibility of adopting a sliding scale method of charging on similar lines to that often offered in connexion with telephone service.

Mr. R. B. Matthews thought that the consumer must be educated to a higher standard of illumination. He also indicated the advisability of inducing customers to utilize electricity for heating and cooking purposes, of increasing the number of consumers, and of trying to decrease the cost of house-service. He, too, thought that the maximum demand system was not understood, and a cause of trouble with consumers.

Mr. W. M. Morday said that the maximum demand system had proved undesirable in practice. Three years ago there were three times as many M.D. systems in use as flat rates. Now the condition of things was reversed. He advocated an attempt to approach nearer to the broad, free methods of dealing with the consumer employed by the gas companies.

Col. Crompton remarked upon the different condition of things to be met with in different districts. Naturally the effect of the new lamp depended very greatly on whether the ground had been already very fully covered or whether there was room for much further extension. This was partially responsible for the different points of view, pessimistic or otherwise, as to the influence of metallic lamps on revenue. We had, however, now arrived at a condition of affairs such that it was almost impossible to reduce the first cost of electricity very much, except by securing an enormous output or splendid load-factors. He thought that the Norwich system of charging introduced by Mr. Long at Norwich was one of the most important points in the paper, and regretted that it had not received fuller discussion. It resembled the ordinary water-rate, and would be largely instrumental in getting over the injustice done to the small consumer.

Mr. A. H. Dykes, in reply, stated that some present thought that they had taken an unduly pessimistic view of the situation, but that this was not really so. He showed several load-curves to illustrate the falling off in energy supplied during the present year. As a whole the curve for 1907 fell below that for 1906, and, occasionally, even below the corresponding value for 1905. On the whole, however, he thought that the discussion endorsed his view that the metallic filament lamps might lead to considerable reduction in revenue unless some efforts were made to put things on a more satisfactory footing. Certainly even their immediate effect was very serious in the case of large consumers using perhaps £2,000 per year. Mr. Wright had suggested that the public ought to be educated to use more light, but had we any solid reason to hope that they could be induced to do so?

He was glad to see that the disadvantage of the maximum demand system, and also the inequality of the flat rates were widely recognized, and that modifications of the system which the authors proposed had been adopted by Mr. Long and others. As a matter of fact, a very similar system had been advocated by Messrs. Tate and Bowden in 1906.

Some scheme of the kind he felt to be very desirable, and thought that the Board of Trade would sympathetically consider any suggestions that the Institution might put before them on the subject.

Recent Progress in Tungsten Metallic Filament Lamps.

By H. Hirst, Member.

(Paper read before the Institution of Electrical Engineers, May 21st, 1908.)

In the first part of the paper the author deals briefly with the early work of Swan, Edison, and others on metallic filaments. He explains the immediate success of carbon applied to the manufacture of glow-lamp filaments, and traces the subsequent attempts to employ rare metals which culminated in the invention of the osmium lamp by Auer von Welsbach. These steps have been so comprehensively described in *The Illuminating Engineer*, in the recent articles by Dr. Weber and Dr. Jacobsohn, that it is unnecessary to do more than mention a few of the developments on which the author lays stress.

Mr. Hirst, however, goes on to mention the work of von Bolton on the tantalum lamp, which was put on the market in 1905. Afterwards attention was turned to tungsten, and Siemens and Halske attempted to apply their drawing process, which had been successful in the case of tantalum, to tungsten; they failed, on account of the brittleness of the latter metal.

The well-known patent of Just and Hanaman was obtained in 1904. The patents of the Deutsche Gasglühlicht Aktiengesellschaft were worked out independently. Both deal with the manufacture of filaments from pure tungsten. These two fundamental patents refer to the paste-process. Other patents have been taken out by :—

Heany (American patent No. 839,585), who proposes to use an alloy of tungsten with titanium.

Kuzel (British patent No. 28,154 of 1904) suggests the manufacture of glowing bodies from colloidal metals.

British Thomson-Houston Company, (British patent No. 18,749 of 1906 and subsequent patents) describes the manufacture of filaments of tungsten with the help of volatile metals or alloys, chiefly amalgams, which could be drawn into wire. It will be interesting to watch the progress of this suggestion

Zerning (British patent No. 2,554 of 1906) claims the use of hydrogen and nitrogen compounds of tungsten as the materials from which to construct tungsten filaments.

Mr. Hirst, however, contends that only the two original patents referred to above have yet been successful in producing commercial lamps. All metallic filaments burning at a consumption of 1 watt per candle have been made with tungsten filaments. If ever so small percentages of other substances are added to the tungsten, the economy and useful life of lamps with such filaments suffer immediately.

The osram lamp is manufactured by the "paste" process, the principle of which consists in preparing from solid substances, such as the metals themselves, in the most finely divided form, a paste with binding or stiffening agents such as the gums, dextrine, and other similar bodies. Such a mass has the consistency of putty, and is then squirted through a very fine orifice in a diamond, with a pressure of several tons per square inch. The result of the squirting operation is that one obtains a somewhat moist thread, which, however, has enough coherence to be formed into filaments that do not break while being dried.

The filaments are first heated under exclusion of air and then possess sufficient strength to be held in metal clamps. They are then subjected to the passage of an electric current which raises them to a high temperature, causing the filaments to sinter. The filament so obtained is dense and homogeneous, but being obtained by a sintering process it is different in structure from the still denser metal which would be obtained from a melted mass.

Auer von Welsbach describes a method for the manufacture of an electrical illuminating body of osmium by sintering the most finely divided metal at such a high temperature that platinum would

evaporate, which temperature destroys the binding material which had been used in the manufacture of the threads. The filament so obtained withstands a very high temperature, but it is still of a more or less spongy or porous constitution; very metallic, but nearly solid. During the process there is a considerable shrinking in the material of the filament amounting in all to about 55 per cent.

The other method of constructing tungsten filaments was developed by Drs. Just and Hanaman simultaneously with, but quite independently of, the Deutsche Gasglühlicht Aktiengesellschaft. Their lamp was introduced commercially under the name "Just-Wolfram." This process is carried out as follows: Ordinary carbon filaments of very small diameter, 0·02 to 0·06 mm., are raised to a bright red heat by means of an electric current in an atmosphere of volatile tungsten compounds in the presence of hydrogen.

The heat of the filament causes the hydrogen to reduce the volatile metallic compounds, depositing the metal in homogeneous condition on the carbon filament.

The filaments are next submitted to the action of an electric current in an atmosphere of highly rarified inert gas, such as, for example, hydrogen at a pressure of about 20 mm., until they show the clearest white incandescence. This process causes the carbon to combine with the tungsten surrounding it, forming a carbide.

Finally, they are raised to a high temperature through the passage of an electric current while surrounded by a mixture of hydrogen and a little steam. This causes the carbon to be oxidized by the same reactions which go on in the water-gas process.

Drs. Just and Hanaman have also obtained patents protecting the process of *mounting* their tungsten filaments to the leading-in wires. This is effected by means of a paste consisting of finely divided tungsten metal mixed with coal tar or gum. These paste mounts are dried and finally made red-hot by any suitable means before the filament is heated in the bulb.

The supports used in these lamps are made of suitable metal.

Exhausting is done in a manner similar to that employed for carbon lamps.

Though this process is entirely different from the "paste" process, the final result in each case is a pure, sintered filament of tungsten metal. The sole difference is that the filament made by the Just and Hanaman process is tubular.

It has been proved that these lamps will burn for from 1,000 to 2,000 hours with a consumption of about 1 watt per candle-power, without any appreciable falling off in the candle-power. Of all the metals which have been experimented with up to now, only pure tungsten has such a life.

In economy, the result is also better than has been obtained with other filaments, thus:—

The osmium filament takes 1·5 watts and the tantalum 1·7 watts for direct current, and somewhat more for alternating.

The results of some recent life tests are shown in Table I.

TABLE I.—LIFE TEST RESULTS.

No. of Test	Type.	Cost per Lamp.	Tested by	Starting.		Efficiency in W./C.P.	Number of Lamps.	Duration of Test.	Average Useful Life.	Mean Efficiency.	Average C.P. Hours.	Cost per 1000 C.P. hours.		
				Watts.	C.P.							Renewals.	Energy at 4d. per Unit.	Total.
	Low Voltage.	d.						Hrs.	Hrs.	W./C.P.	*	d.	d.	d.
I.	Osram	48	Faraday House ...	35·7	36.3	0·99	12	2,000	1,520	1·12	48,700	0·98	4·48	5·46
II.	Osram	48	Westminster Testing Laboratory	35·8	29·7	1·22	12	1,500	1.360	1·29	36,600	1·31	5·16	6·47
II.A*	Osram	48	Westminster Testing Laboratory	35·8	29·7	1·22	12	3,350	2,850	1·42	70,800	0·67	5·68	6·35
III.	Osram	48	T. R. Charlottenburg	34·7	1·0	1·12	?	1,000	1,000	1·11	31,100	1·54	4·44	5·98
IV.	Osram	48	Robertson, H. L., Ltd.	35·0	27·7	1.26	6	1,800	1,720	1·36	45,600	1.06	5· 4	6·50
V.	Wolfram	48	Robertson, H. L., Ltd.	38·0	30·7	1·24	2	1,000	1,000	1·27	28,900	1·66	5·08	6·74
VI.	Tantalum	33	Westminster T. L. ...	39·1	22·0	1·78	6	1,000	700	1·84	15,000	2·19	7·36	9 55
VII.	Carbon	12	—	59·0	18·7	3·15	10	1,000	1,000	3·25	18,000	0·67	13·00	13·67
	High Voltage.													
VIII.	Wolfram	90	Robertson, H. L., Ltd.	63·4	53·7	1·18	10	880	720	1·12	42,500	2·12	4·48	6·60
IX.	Carbon	12	—	68·0	18·9	3·6	10	1,000	1,000	3·95	18,200	0.66	15·80	16·46

NOTE.—For the purpose of comparison *all* the above results have been expressed in terms of the "Hefner" unit of candle-power.

* This is a continuation of Test II. to 3,350 hours to show that it pays to burn osram lamps to the limit of life.

The author next refers to the curious fact that whereas the osram filament appears to radiate only 87 per cent. of the energy radiated by an equal surface of a carbon filament, yet it gives about 275 her cent. more light. The author attributes this to the selective radiation exercised by the metallic filament, in virtue of which the temperature of an osram lamp may be about 100 degrees lower than that of a carbon filament lamp of the same efficiency; otherwise it would have to be burnt at an efficiency of 1·5 to 1·6 watts per candle-power in order to have the life which it actually enjoys at 1·1 watts per candle-power. Mr. Hirst also refers to the well-known fact that metallic filament lamps are very much less affected by alterations in P.D. than the carbon ones. In this connexion he gives the curves shown in Fig. 1.

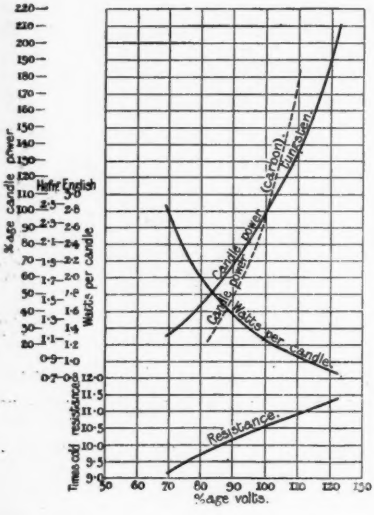


FIG. 1.

The candle-power of a carbon filament lamp, due to a 6 per cent. change in P.D., is as much as 34 per cent.; in the case of the osram lamp the corresponding change in candle-power is only 21 per cent.

HIGH-VOLTAGE LAMPS.

High-voltage metallic filaments of the osram type have recently been put upon the market, manufactured both by the D.G.A. and the Just-Hanaman processes. The average life of a 1 watt 1 candle-power lamp seems to be between 800 and 1,000 hours. During this period there is no appreciable drop in candle-power, and the lamps have shown themselves to be equally good as the low-voltage osram or Just lamps. These high-voltage lamps, made for from 200 to 250 volts, require double the number of filaments used in the low voltage lamps. It is evident, therefore, that they cannot be produced for small candle-power. Up to the present 40 to 50 candle-power is about the lowest unit that has been obtained in a commercial lamp, and some extraordinary development or discovery will have to be made before that candle-power can be largely reduced.

THE USE OF 110 VOLT LAMPS ON 220 VOLT CIRCUITS.

In so far as the lamp is different from the carbon lamp, it will, therefore, always be necessary to rely on series running whenever low units of light are required on high-voltage circuits; thus, for public lighting (especially for the lighting of large spaces), the convenience of one lamp will be apparent, and people will stretch a point to use 50 candle-power for such purposes whenever they can; but for the use of private houses and confined spaces it will always be necessary to revert to lamps burning in series.

This running of osram lamps in series can be avoided to a very large extent in those areas where the supply is given on the alternate-current system.

These tungsten filament lamps burn equally well on either continuous or alternating current, and are quite independent of both frequency and wave form.

THE EFFECT OF METALLIC FILAMENT LAMPS ON SUPPLY SYSTEMS.

Fears have been expressed by some electrical engineers that the introduction of these osram lamps will seriously affect the finances of supply undertakings. Exactly the same fears were expressed by gas engineers when Welsbach mantles were introduced, which enabled the gas required to produce a given quantity of light to be reduced to one-third of that previously used. These fears proved groundless, and the demand for gas increased instead of decreased. The same result will probably follow the commercial use of the metallic filament lamp. It seems likely that the introduction of these lamps will mean an increase of 100 per cent. in the unit adopted for electric light. 16 candle-power carbon lamps will be replaced by 25 to 35 watt tungsten lamps, and those places in which a low illumination is desired will still be supplied

with carbon filament lamps of 2½, 5, and perhaps 8 candle-power. As it is not practicable at present to make osram lamps for 110 volts circuits of a lower candle-power than 25, it is likely that in small rooms greater illumination will have to be used.

Amongst the disadvantages of the lamp is the *burning in vertical position*, which up to now has been insisted upon by the manufacturers. This problem is already solved in different ways, and lamps can now be supplied to burn in any position.

The price of these lamps is for the moment a trifle higher, but before many months I believe they will be supplied at the same price as the others.

The *price* itself is naturally held up as a disadvantage, especially when a consumer is displacing old lamps for new ones. The outlay then appears serious, but the saving in current for given illumination rapidly wipes off this expenditure.

Much has been made of the brittleness of the metallic filament and of the percentage of *breakage* in certain instances. From the moment it was understood how to pack the osram lamp the breakage in bulk has been a negligible quantity. It now only affects the supply of the lamps in small parcels of one half-dozen to one dozen. This problem is now being dealt with, with every prospect of an early success.

Another point about which there has been considerable outcry is the *blackening* of individual bulbs which occasionally occurs. It is at present thought that this blackening is due to some extent to the great sensitiveness of the filament to small changes in vacuum. Other theories exist as to the cause of this, but what for the moment mainly interests the users is that if a lamp is going to blacken it usually happens at a very early period of its life, when the makers are prepared to deal with the matter generously. It is quite different in this respect to a carbon lamp, in which a blackened bulb means as a rule that the lamp has been kept on circuit for an indefinite period, far exceeding its useful life.

TABLE II.

DETAILS OF IRON LOSSES OF SMALL TRANSFORMERS.

Output of Transformer in Watts.	Number of 16-c.p. Osram Lamps Alight at one Time.	No Load.	Iron Losses.	Units taken per Year.	Cost per Year at 4*d.* per Unit.
		Watts.	Per Cent.		£ *s.* *d.*
300	19	5	1·67	44	0 14 8
750	47	10	1·33	88	1 9 4
1,500	94	17	1·13	149	2 9 8

The cost per year at 4*d.* per unit is given in the last column.

TABLE III.

ANNUAL COSTS FOR CURRENT ON AN INSTALLATION OF 25 16-C.P. LAMPS, OF WHICH 19 ARE BURNING AT ONE TIME.

(16-watt Osram Lamp *v.* 60-watt Carbon Lamp.)

No. of Hours per Annum at Maximum Load.	Maximum Load in Watts.		Units used per Annum with Osram Lamps.			Units used for Carbon Lamps.	Cost of Current at 4*d.* per Unit.					
	Osram Lamps.	Carbon Lamps.	Osram Lamps.	Transformer.	Total.		Osram Lamps.			Carbon Lamps.		
							£ *s.* *d.*			£ *s.* *d.*		
300	304	1,140	91	44	135	342	2	5	0	5	14	0
400	304	1,140	122	44	166	456	2	15	3	7	12	0
500	304	1,140	152	44	196	570	3	5	3	9	10	0
600	304	1,140	182	44	226	684	3	15	3	11	8	0
700	304	1,140	213	44	257	798	4	6	6	13	8	0
800	304	1,140	243	44	287	812	4	15	6	15	4	0

Saving.		
£	*s.*	*d.*
3	9	0
4	16	9
6	4	9
7	12	9
9	1	
10	8	

Table IV. shows the complete balance sheet obtained by adding the cost of current to the lamp renewal charges for both carbon and osram lamps.

Finally the author discusses a few special applications of metallic filament lamps. He points out the value and special merits of low pressure 25-volt lamps, used in connexion with a transformer. He refers to the general impression that the iron loses in such small transformers, which, unless special precautions are adopted, go on continuously, are so serious as to nullify the gain in efficiency from the lamps. In the table shown below the iron loss on a transformer taking 3,000 watts is assumed to be 5 watts.

The copper losses in these transformers are not large, and only occur when the lamps are being used.

The following table shows the financial results from the use of these 25-volt 16-c.-p. osram lamps in a private house requiring 25 lamps. It is assumed that the smallest size of transformer in the preceding table will suffice, as 19 lamps alight at one time is about the extreme maximum load in such a house.

houses, workshops, &c. Where small units of light are quite sufficient, the cost of the generating plant can be reduced very largely as the output required falls in the ratio of the efficiency of the filaments used in the lamps.

The same reduction in the cost of generating plant in mains can be realized when designing electric lighting equipment for the numerous small towns and villages within the United Kingdom

TABLE IV.

No. of Hours per Annum of Maximum Load.	Osram Lamps.		Carbon Lamps.		Total.		Total Saving with Osram.	
	Current.	Lamp Renewals.	Current.	Lamp Renewals.	Osram Lamps.	Carbon Lamps.		
	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	Per cent.
300	2 5 0	1 10 0	5 14 0	7 1	3 15 0	6 1 1	2 6 1	38
400	2 15 3	2 0 0	7 12 0	9 6	4 15 3	8 1 6	3 6 3	41
500	3 5 3	2 10 0	9 10 0	11 10	5 15 3	10 1 10	4 6 7	43
600	3 15 3	3 0 0	11 8 0	13 3	6 15 3	12 1 3	5 6 0	44
700	4 5 6	3 10 0	13 6 0	16 7	7 15 6	12 2 7	6 7 1	45
800	4 15 6	4 0 0	15 4 0	19 0	8 15 6	16 3 0	7 7 6	45½

These tables show that private houses in those areas over which electricity is distributed in the form of alternating current can at once realize to the full the exceptional radiating properties of the tungsten filament.

There is another large field for these low voltage lamps in connexion with isolated plants for the supply of country yet to be supplied with electrical energy. In such undertakings the capital burden to be borne by the relatively few consumers obtainable is the chief deterrent.

While the saving from the use of the metallic filament lamp may not bring the capital down quite in the above ratio, it will make many schemes feasible which hitherto have been passed by.

Publications Received.

The Annual Report of the Lighthouse Board, Washington, U.S.A.

A REPORT giving exhaustive particulars of the various lighthouses, beacons, buoys, &c., in use in the United States.

It contains a series of maps referring to the sixteen districts dealt with, is excellently arranged and indexed, and should be found of great value by all interested in the subject of lighthouse illumination.

Die Revision elektrischer Starkstromanlagen. By Paul Stern. (Mk. 3.60., Hannover, Max Jänecke.)

This little book describes the inspection of heavy current installations. In the first section the author classifies the various kinds of inspection to which electrical installations are subjected; in the second and third sections he reviews the possibilities of injury to men and things, either accidental or arising from imperfect electrical conditions. In the third and longest section he gives a summary of the existing legislation, regulations, and statistical data in Germany bearing on the subject.

Isolationsmessung und Fehlerortsbestimmung in elektrischen Starkstromanlagen. By Paul Stern. (Mk. 1.60., Hannover, Dr. Max Jänecke.)

In this little book the author deals in a condensed manner with the existing methods of testing insulation, and locating faults in electrical installations.

The arrangement of the book is such as to present the available data in a readily accessible form, and the numerous and clear illustrations provided constitute an important and excellent feature in a book devoted to this subject.

Working Standards of Light and their Use in the Photometry of Gas.

By Chas. A. Bond.

(Abstracted from the *Journal* of the Franklin Institute, March, 1908.)

In this paper the author describes and reviews the various standards of light utilized in the United States for gas-testing. Among these standards occur some of those which have recently been described by Mr. Trotter in *The Illuminating Engineer*, but also some others which are exclusively used in America. In particular the experiences of the United States as regards our own standard, the 10 candle-power pentane lamp, are of interest.

The Vernon Harcourt lamp was legally adopted by the Gas Referees in this country about ten years ago. Since that date as many as 150 of these lamps, or reproductions of them, have found their way into use in the United States, and have given very satisfactory results. In order that a lamp may serve as a standard, the luminosity may be maintained constant, (1) by securing a uniform consumption of fuel, and (2) by the maintenance of a constant height of flame. In spite of the greatest care in specifying the construction and opacity of lamps, however, it is impossible to secure the reproduceability of the light to within a few per cent.

The Reichsanstalt in Germany, for instance, certify Hefner lamps, the candle-power of which falls within ± 2 per cent of the standard.

Of the sixty-four pentane lamps that have been standardized by the photometrical department of the Philadelphia gasworks, by comparison with an imported English lamp certified by the Gas Referees, eight have differed more than 1½ per cent from the standard value. Three of these did so owing to errors in construction.

As an instance of the great constancy in the light of a given lamp that is possible the author quotes the following experience. An English lamp (No. 51) was imported from London in January, 1900, and certified to give a value of 10 candles. In 1904, as a mean of sixty readings, an American lamp (No. 2) proved to have a value of 10·04 candle-power, expressed in terms of this English lamp.

In 1905 a second American lamp (No. 89) was compared with No. 2, and found to have 10·02 candle-power, as the mean of a hundred readings.

In 1907 this last lamp (No. 89) was taken to London, and, tested by the Gas Referees against their own standard, proved to have a value of 9·99 candles, which represents a discrepancy of only 0·3 per cent as compared with the American value. From the point of view of gas-testing, therefore, the pentane lamp appears to possess the desired constancy as a unit of light.

The author then proceeds to mention the requirements of a good working standard, which are as follows :—

1. That it should be readily portable, of simple construction and operation, and of unvarying dimensions.

2. It should have an independent fuel, reasonable in price and readily procurable, of definite chemical composition, with a fixed boiling point.

3. The flame should be of the same order of luminosity as the test flame ; of a similar colour ; fed without a wick ; at a constant pressure, through a constant opening ; and no chimney should intervene between it and the photometer disc.

4. The lamp should be burnt in a quiet, adequately ventilated room of uniform temperature, and be supplied with pure air of the same temperature. After reaching thermal equilibrium its flame height should be set, and, all the conditions named above having been complied with, the flame height and flame value will remain unchanged for that particular atmospheric condition.

5. It is known that all flames, being supported in combustion by atmospheric oxygen, are influenced by the condition of that atmosphere as regards carbonic acid content and water vapour content. It is desirable, therefore, that the luminosity of the standard used should, as far as possible, be influenced in the same direction and to the same extent as the

test flame. In this way the correction in value is automatic.

Common Working Standards.

Reports were received by the American Gas Institute from the gas companies in about eighty of the largest cities of the United States, showing the following working standards to be in use :—

A.—British candles of several importations. Used by 31 of the 40 municipal and State inspectors, and by 41 gas companies.

B.—Edgerton Standard, used by 18 gas companies; no municipal or State inspectors.

C.—Hefner lamps, used by 1 municipal inspector; 5 gas companies.

D.—Electric incandescent lamps, used by 2 municipal inspectors; no gas companies.

E.—Elliott lamp, used by 11 gas companies.

F.—Pentane lamp, used by 31 gas companies and three municipal inspectors.

G.—Jet photometers, variously manipulated, used by 28 gas companies, 20 of which also use bar photometers.

Of these working standards we may eliminate from consideration D (electric incandescent lamps) and G (jet photometers); D because no companies use it, and for the reason that it is unaffected by atmospheric changes, and so is unsuited for testing gas flames which are so affected; G for the reason that while by flame phenomena it serves to indicate the direction of change in candle-power, and can be calibrated fairly well, yet in the true sense it is not a photometer, and makes no use of the light standards under discussion. In justice to the electric incandescent lamp it should be said that it is to-day the most trustworthy custodian of the unit of light, and is employed at the Bureau of Standards for that purpose.

A. *Candles.*—Candles have the weight of long usage behind them, are mentioned in many contracts, and are simple and easily set up. They also yield a light of a convenient colour.

Otherwise (though still frequently employed) they are now recognized as being very irregular and unsatisfactory standards, even when carefully used. Thus the Dutch Photometrical Commission found the average deviation to be 2·87 per cent, and the individual variation as much as 9 per cent from the normal. In order to secure standard conditions attention must be paid to a very large number of different factors. The last specification issued in 1894 contains such minute directions as to be rarely complied with by manufacturers. Then again the performances of candles are very much affected by atmospheric conditions, and under certain climatic conditions it may be impossible to secure the standard burning rate at all. Candles imported from different sources also vary among themselves very greatly. The number of threads per strand, the melting point of the wax, and the curvature of

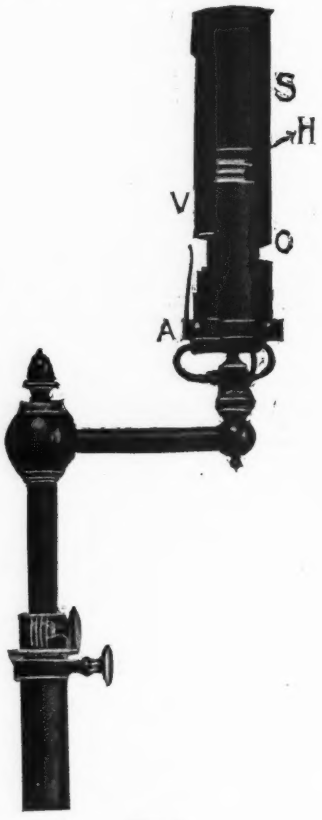


Fig. 1.
Edgerton Standard.

the wick during burning, all affect the luminosity of the flame. The author has found variations as high as 11·5 per cent above and 7·5 per cent below the standard candle-power.

Lastly, the actual manipulation of the candle as a standard presents many inconveniences.

B. *The Edgerton Standard.*—This standard, which is shown in Fig. 1,

appears to be a modification of the Methven screen, long used in England as a standard lamp.

The standard consists of a Sugg D argand burner with a 7 in. × 1¾ in. chimney, surrounded by a blackened brass sleeve. In the front of this sleeve, with its lower edge ⅞ in. above the top of the steatite ring of the burner, there is cut a slot 1⅛ in. high and of such width as to include the entire diameter of the flame.

Theoretically, if the flame be adjusted to a height of 3 in., the portion visible through the slot will remain practically constant in intensity, for ordinary variations in the illuminating power of the gas fed into it. Actually with coal-gas of candle-power varying from 13 to 17, its value alters from about 4·20 to 4·6.

A number of tests by Mr. Rollin Norris, published in 1899, led him to conclude that the standard could be relied upon to give results, the error of which would not exceed 1½ candles, while most observations would be correct to within one candle of the true illuminating value of the gas.

This standard is, however, said to give good results if carefully used, and is frequently employed as a substandard in connexion with the pentane lamp.

C. *The Hefner Lamp.*—(This standard has been previously described in *The Illuminating Engineer*, by Mr. A. P. Trotter, January, 1908, p. 10.)

D. *The Elliott Lamp.*—The general nature of this standard will be gathered from Fig. 2. A high grade of petroleum oil is burnt by means of a flat wick, the glass chimney being large and bulbous in order to allow of a screen within. The screen being relatively near to the flat flame, does not call for a correction of the position of the radiant centre as in the case of the Edgerton standard.

The lamp is painted black, and has an acorn-shaped reservoir, capable of holding about 500 cc. of oil, the normal rate of consumption being 1 cc. per minute.

The trimming of the wick is a very essential operation, and must be carefully looked to. After burning twenty minutes, so as to gain thermal equilibrium, the lamp is ready for standardization and subsequent use. After this it should not be touched again, and, it is said, yields a very constant light until the reservoir is depleted. It is also claimed that a wick will last about 200 hours before capillarity is impaired; but it is desirable to standardize the lamp frequently. The mean intensity of the lamp approaches 10 candle-power very closely Thus the mean value of 550 readings from April 17th to April 23rd was found to be 9·957, the lowest value being 9·76, and the highest 10·21.

Like other flame-sources the lamp is affected by atmospheric conditions, though, it is said, to a very similar extent to the pentane lamp.

F. *The Pentane Lamp.*—(This lamp has already been described in *The Illuminating Engineer*, Trotter, January, 1908, p. 9).

It is to be noted that although the dimensions of the lamps are the same,

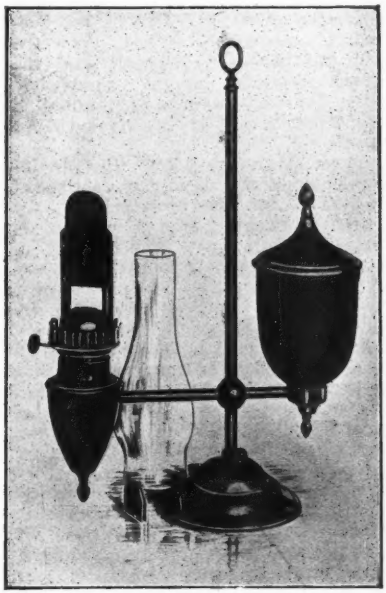


FIG. 2.
ELLIOTT STANDARD.

there are several details in construction that differ. For instance, a metal tube is used to convey the pentane vapour to the burner in preference to a rubber one. Again, what seems a rather essential difference, the position of the cross-bar in the mica window is lower, it being customary in America to regulate the top of the flame to this bar, instead of maintaining it half-way between the bar and the base of the window. It is interesting to note that the author considers that of all the standards mentioned, the pentane lamp is far the best both as regards convenience and reliability.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

THE æsthetic and physiological aspects of illumination are still receiving a considerable amount of attention in the United States. Mention has already been made of the recent papers of G. L. Hunter and E. L. Elliott dealing with the former aspect, and that of Dr. Seabrook on the effect of light upon the eye: the two former papers and the ensuing discussion are now published in the *Transactions* of the Illuminating Engineering Society for March and April respectively.

Among other papers from the physiological standpoint we may note that of Dr. J. T. Krall. He considers that the superior illuminating power of modern sources is no drawback from the physiological point of view—is, indeed, necessary for the arduous work of the present day, provided such sources are properly shaded. He suggests that the main injury caused by artificial light arises through too great intrinsic brilliancy rather than any peculiarity in colour. He recognizes, however, the indisputably evil effect of excess of ultra-violet rays, and gives a resumé of the recent literature on the subject.

Dr. Miles Standish likewise insists upon the importance of avoiding intrinsic brilliancy, and in addition makes the suggestion that light coming from unusual angles must be considered bad; our eyes are naturally adapted to receive light from above.

L. W. Marsh describes the Luxfer system of utilizing daylight to the best advantage by means of prismatic glass, the object being to prevent the production of inconvenient shadows from light coming at a certain angle, and to distribute it in any desired direction.

H. W. Castor discusses illumination from the architect's standpoint. He dwells upon the value of artificial illumination in order to accentuate certain architectural features of a building, and quotes particulars of the illumination in a number of churches; in this connexion he points out that, from the æsthetic standpoint, the main illumination should be distributed over the chancel in order to give this part of the church special prominence.

F. C. Dickey states the point of view of the fixture manufacturer, who is really anxious to adopt efficient and artistic types of fixtures, but who is naturally forced to compromise his ideals owing to the necessity of satisfying the prevalent taste which, unfortunately, often elects to admire showy fixtures rather than artistic and efficient ones.

Among other recent articles on problems of illumination we may mention that of A. R. Dennington (*Illuminating Engineer*, N.Y., May), who discusses the illumination of streets lined with trees, the foliage of which is found to interfere with ordinary methods of illumination. The author considers that this variety of street is best illuminated by a number of small units, distributed at frequent intervals, rather than concentrated sources of high candle-power.

Niemann and Du Bois (*J.f.G.*, April 18) contribute a continuation of their reecnt historical study of illumination. The present instalment deals with methods of lighting in the Middle Ages, and is illustrated by means of a number of drawings and photographs showing the nature of the huge fixtures used at that time for the lighting of large halls and churches, &c.

Weinbeer (*Elek. Anz.*, April 21) continues his previously published series of articles on the production of uniform illumination by means of various types of artificial illuminants. These he divides into four main classes, according to the nature of their polar curves of distribution of light, and, in the article to which reference is now made, illustrates his previously determined results by several concrete examples.

Schilling (*J.f.G.*, April 18) gives some examples of the degree of illumination found necessary in the *Technische Hochschule* at Münich. Originally 40 lux was provided, but complaints of the poverty of illumination caused a value of 80 lux to be afterwards specified. Ultimately it was found desirable to increase this value to about 112 to 115 lux; under these conditions even one of the lamps failing to work entirely would only reduce the illumination to about 70 lux.

The author shows that the number of lamps required to produce such an

illumination is in fair agreement with the computed value suggested by his own tables.

The Electrical Review (New York), in a recent editorial, lays stress on the necessity of precision in using scientific terms, and makes special reference to the innumerable terms in use to denote intensity of illumination (see also Monasch, abstracted *Illuminating Engineer*, Feb., 1908). Attention is drawn to the convenient and precise terminology sanctioned by the International Photometrical Congress, and particularly the term "lux," which, though somewhat differently used by different nations at present, has certain evident advantages as an international unit.

Among articles of a more strictly photometrical nature reference may again be made to the new graphic method of Dr. Kenelly for determining mean spherical candle-power, which now appears in the *Transactions* of the Illuminating Engineering Society for April.

Schuchardt (*J.f.G.*, May 2) describes the photometrical laboratory of Messrs. Ehrich and Graetz.

The *Sweizerische Elektrotechnische Zeitschrift* (April 25) describes a new portable and enclosed form of photometer produced by Messrs. Siemens and Halske. In this instrument the "angle-mirror" method, sanctioned by the Verband Deutscher Elektrotechniker, is used for the determination of mean horizontal candle-power. One point of interest is the use of a special form of "grease-spot" screen composed of two frosted glass plates, between which is placed a silvered spot.

Electric Lighting.

The number of papers dealing with the metallic filament lamps is this month greater than ever. Chief among these may be mentioned the paper by Mr. Hirst before the Institution of Electrical Engineers in London on May 21st. The author dealt mainly with the tungsten lamps, though he prefaced his subject proper with a short historical introduction. Of the many existing processes for the manufacture of tungsten filaments, he contended that only those of Just and Hanaman and the Deutsche Gasglühlicht Aktiengesellschaft have led to the manufacture of really commercially successful lamps. The author next describes the exact method of manufacture of osram and Just-Wolfram lamps, and alludes to the curious behaviour of the metallic filament lamp in apparently radiating only 87 per cent. of the energy per unit surface that the carbon filament lamp does, and yet giving 275 per cent. more light; this is to be ascribed to some form of selective radiation. Reference is made to the behaviour of osram lamps in actual practice and their probable influence on the lighting industry; some interesting particulars of the loss in small transformers are given.

There are also a number of articles dealing with the more technical side of the question. The *Zeitschrift für Beleuchtungswesen* continues a very comprehensive review of recent patents on the subject, and also contains a more popular article, in which the writer points out the tendency in all kinds of electric lighting to adopt metallic conductors in place of carbon; this is exemplified by the flame arcs, the metallic filament lamps, and the mercury vapour arc.

Duschnitz (*Elek. Anz.*, April 30, May 14) continues his valuable resumé of patents bearing on the details of manufacture, such as the various devices for the attachment of the filaments to the leading in wires.

Lottermoser (*Chem. Zeitung*, No. 25, 25, 3, 1908, also *Elek. u. Masch.*, April 19) reviews the work of the earlier students of colloidal processes—Bredig, Billitzer, Wedekind, &c., and describes the modern methods of producing metals in a colloidal state, as applied to the manufacture of the Kuzel lamps.

Pécheux (*Lumière Electrique*, May 16) contributes the results of some tests on the characteristic properties of the tungsten and other lamps, including details of their alteration in resistance with temperature and consequent relative sensitiveness to fluctuations in P.D., &c.

J. B. Taylor (*Elec. World*, April 25) describes a curious phenomenon exhibited by tungsten lamps. One result of the relatively low heat-capacity of metallic lamps as compared with carbon filament ones, is the rapidity with which they light up. In the case of the ordinary carbon lamps, the eye can usually distinctly perceive the building up of the light, but in the case of the metallic lamps, no such effect is clearly visible. But the author goes further. He himself, when viewing a tungsten lamp lighting up, is conscious of a distinct impression that the lamp exceeds its normal brilliancy for a short time—overshoots the mark, in fact.

Such an impression, which was shared by other observers, might possibly be attributed to purely physiological causes. The author, however, states that he has actually secured photographic demonstration of the effect. At present, there seems no very plausible explanation.

It is interesting to learn that the Edison

Electric Illuminating Co. have come to a decision as regards the question of free renewal of tungsten lamps (*Elec. Rev.*, New York, May 9). The company state that the conditions of manufacture of metallic lamps at present militate against the possibility of giving such lamps free. In future, however, lamps will be supplied at cost, deducting an allowance covering cost of carbon lamps to free renewal customers; thus the 40 or 50 watt tantalum lamps will be supplied at 25 cents. each, subject to the burned-out lamps being returned. This point is also mentioned by Willcox, in a recent lecture (*Elec. Rev.*, N.Y., May 16).

There have also been several articles of interest bearing on arc lighting. Dyott (*Elec. World*, April 25th) describes some experiments upon the magnetite arc. He gives some curves illustrating the relation between current and P.D., and deals at some length with the nature of the spectrum of the arc and the effect of certain impurities, notably chromium, on the colour of the light emitted.

Ladoff (*Illum. Eng.*, New York, April and May) contributes a general review of recent patent literature on the subject of arc-lamps.

Vollhardt (*J.f.G.*, May 20) describes the most recent form of Carbone high-pressure arc. The general advantages of the lamp—its efficiency and the resemblance of its spectrum to daylight, &c., are pointed out, and the results of some recent tests at Charlottenburg given. The chief point of interest, however, is the fact that it seems to be possible to secure, with inclined carbons, a pressure of more than 80 to 90 volts across the arc.

Gaslighting, &c.

The most interesting event in gas-lighting during the past month has been the publication of the tests by Mr. Herring of the lighting at the National Scottish Exhibition, including those on the new Keith high-pressure lamp. According to these tests, which receive detailed comment in the *Gas World* and the *Journal of Gaslighting*, it is now possible, in the Keith lamp, to secure the exceedingly high efficiency of from 60 to 70 candle-power per cubic foot of gas. Yet the result seems to have been achieved without the introduction of any very novel device, and to be attributable merely to the exceptionally perfect conditions secured by the combined effects of high-pressure and heating the combustible mixture. The mantle used is also exceptionally long and narrow, the length being given as $3\frac{5}{8}$ in. and the width as $1\frac{1}{4}$ in. in the case of a 1,500 candle-power lamp. Four of these lamps are now erected in Kingsway, London.

Among other articles we may mention the review of existing patents on inverted burners and mantles to be found in the *Zeitschrift für Beleuchtungswesen* (May 10).

A. Granjon (*Rev. des Eclairages*, May 15) discusses the value of different combustibles as a means of rendering mantles, &c., incandescent. He points out the distinction between the heat of combustion and flame-temperature. The former is a constant quantity for the same combustible; the latter, on the other hand, depends upon the exact conditions of use. Thus acetylene yields about 14,000 calories, but its flame-temperature may vary from 2,500 to 4,000 degrees, according to the burner used and other conditions.

The *Zeitschrift für Beleuchtungswesen* (May 20) contains a discussion of the relative merits of high-pressure gas systems and systems in which the air and gas in the burner are brought into intimate mixture by being churned together or other mechanical means. Our only object in either case is to enable the gas to get as much contact with the air in which it burns so as to cause it to burn quickly and reach a high flame-temperature; for it is on the value of this temperature that the efficiency of an incandescent solid mainly depends. We may accomplish this result by injecting gas at a high pressure. In practice pressures greater than about $\frac{1}{10}$ to $\frac{1}{8}$ of an atmosphere are rarely used. In the Salzenburg lamp, it is true, as high a pressure as 1·1 atmospheres was actually used; but this lamp does not seem to have found its way into practical use in this form as yet.

The author, however, evidently prefers the method of causing a mixture of gas and air by some arrangement not involving the supply of high-pressure gas.

Lastly, mention must be made of a recent article by Schäfer (*J.f.G.*, April 25) dealing with the illumination of interiors by means of gas. The author lays stress upon the necessity for studying the distribution of light in such cases, and the value of the inverted lamps, which may be arranged to throw the light just where it is needed.

The article is accompanied by a series of photographs showing the fixtures employed and their position for the illumination of various types of rooms.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Castor, H. W. Modern Methods of Illumination from the Architect's Standpoint (T. I. E. S., April).
Dennington, A. R. The Illumination of Shady Streets (*Illum. Engineer*, N.Y., May).
Dickey, F. C. Lighting Fixtures from the Manufacturer's Standpoint (T. I. E. S., April).
Dow, J. S. Some Physiological Effects of Light (*Illum. Engineer*, N.Y., April).
Editorials. The Careless Use of Scientific Terms (*Elec. Rev.*, N.Y. May 9).
Illumination and the Municipal Councillor (J. G. L., May 12).
Illumination Contracts and Tests (J. G. L., May 19).
Elliott, E. L. The Relation of Illuminating Engineering to Architecture from the Engineer's Point of View (T. I. E. S., April).
Hunter, G. L. Light and Colour in Decoration (T. I. E. S., March).
Kenelly, A. E. A Graphical Construction for the Spherical Reduction-Factor of a Lamp (T. I. E. S. May).
Krall, J. T. Eyesight and Artificial Illumination (T. I. E. S., March).
Lux, H. The Efficiency of Artificial Illuminants (J. G. L., April 28, March 12, translated).
Marsh, L. W. Daylight Illumination (T. I. E. S., March).
Nieman and Du Bois. Zur Geschichte des Beleuchtungswesens (J. f. G., April 18).
Schilling. Bemessung der Stärke der Lichtquellen für indirekte Beleuchtung mit Gasglühlicht (J. f. G., April 18).
Schuchardt, G. Lichtmessung in der Praxis der Gasbrennerfabrikation (J. f. G., May 2).
Standish, M. Artificial Illumination from a Physiological Point of View (T. I. E. S., April).
Weinbeer, W. Reflektoren für konstante Bodenbeleuchtung (*Elek. Anz.*, May 21).
Neue tragbare Photometriereinrichtungen (Schweiz. E. T. Z. April 25).

ELECTRIC LIGHTING.

Canning, J. H. Some Notes on New Electric Lamps (Discussion). (J. G. L., May 12).
Duschnitz. Die Verbindung der Glühfäden mit den Elektroden (*Elek. Anz.*, April 30, May 14).
Dyott, G. M. The Magnetite Arc (*Elec. World*, April 25).
Handcock, H. W. and Dykes, A. H. Electric Supply Prospects and Charges as Affected by Metallic Filament Lamps (Discussion). (See Elec. Press of Current Date.)
Hirst, H. Recent Progress in Tungsten Metallic Filament Lamps (Paper read before Institution of Electrical Engineers in London, May 21).
Huguenin, P. A. La Lampe à vapeur de mercure (*Lumière Electrique*, April 25).
Ladoff, I. Recent Progress in the Voltaic Arc (*Illum. Engineer*, N.Y., April and May).
Lottermoser, A. Einige Bemerkungen über die Herstellung von Metallfäden für elektrische Glühlampen, besonders aus kolloiden Metallen (*Chem. Zeitung*, No. 25, 25, 3, 1908; also *Elek. u. Masch.*, April 19).
Pécheux, H. Du Regime de Fonctionnement Electrique des Lampes à Incandescence à Filaments Metalliques (*Lumière Electrique*, May 16).
Taylor, J. B. The Overshooting of Tungsten Lamps (*Elec. World*, April 25).
Vollhardt, E. Die Carbone-Hochspannungbogenlampe (J. f. G., May 23).
Wilcox, F. W. The New Incandescent Lamps (Paper read before Iowa Electrical Association, *Elec. Rev.*, N.Y., May 16).
The Stearn Metallic Filament Lamp (*Elec. Engineering*, April 30).
Small Transformers for Metallic Filament Lamps (*Elec. Engineering*, May 7).
Two Recent Patents Referring to Metallic Filament Manufacture (*Elec. Engineering*, May 14).
Metallic Filament Lamps for Street-Lighting (*Elec. Engineering*, May 14 and 21).
Fortschritte in der Glühlampen-Industrie (*Z. f. Bel.*, May 20).
Die Wanderung des Elektrischen Lichtes von der Kohle zum Metall (*Z. f. Bel.*, May 20).
Fortschritte, &c., Elektrische Beleuchtung, Bogenlampen, Glühlampen, Quecksilberdampfbogen (*Elek. u. Masch.*, April 19, 26).

GAS LIGHTING, OIL LIGHTING, ACETYLENE, &c.,

Editorial, A Big Increase in Efficiency (J. G. L., May 5, G. W., May 9).
Granjon, A. Les différents modes d'éclairage par l'incandescence (*Rev. des Eclairages*, May 15).
Schäfer, F. Das Gasbeleuchtung von Innenräumen (J. f. G., April 25).
Thomson, G. W. Extension of Gas for Illumination (T. I. E. S., March).
Gaslighting at the Franco-British Exhibition (G. W., May 9).
The New Keith Lamp (G. W., May 9).
Sixty to Seventy C.P. per Cubic Foot of Gas (J. G. L., May 5).
Neue Invertbrenner (*Z. f. Bel.*, May 10).
Pressgas oder Pressluft (*Z. f. Bel.*, May 20).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
Elektrot. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
Z. f. Bel.—*Zeitschrift für Beleuchtungswesen.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society.*

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

8,298. Choking coils for arc lamps (C.S.). April 14. L. O. Langworthy, 53, Chancery Lane, London.
8,308. Arc lamps. April 14. W. J. Davy, 40, Chancery Lane, London.
8,375. Arc lamps. April 15. A. D. Jones, Hartham Works, Hartham Road, Holloway.
8,421. Filaments for incandescent lamps (C.S.). April 15. (I.C. May 13, 1907, Germany.) Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.
8,494. Luminous signs, &c., for advertising. April 16. E. V. Gratze, 44, Whitfield Street, London.
8,737. Filaments or bodies for incandescent lamps (C.S.). April 21. C. A. W. Hopton, 4, South Street, Finsbury.
8,746. Incandescent filaments (C.S.). April 21. G. Auger, 18, Southampton Buildings, London.
8,773. Electric lamps. April 22. E. Böhm, 45, Hillmartin Road, London.
8,848. Incandescent lamps. April 23. W. K. Dickson and H. J. G. Reeser, 61, Strand, London.
8,991. Arc lamps. April 24. The Electrical Co., Ltd., and F. Schaefer, 83, Cannon Street, London.
9,097. Holders for tungsten filaments in lamps (C.S.). April 27. (I.C. Feb. 13, 1908, Germany.) Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 55, Chancery Lane, London.
9,222. Arc lamps. April 28. C. A. Carpenter and O. T. Banks, 49, Mortimer Street, London.
9,241. Arc lamps. April 29. A. D. Jones, Hartham Works, Hartham Road, Holloway. (Addition to 3,060/07.)
9,257. Incandescent lamps. April 29. J. Cochran, 17, St. Ann's Square, Manchester.
9,501. Arc lamps (C.S.). May 1. H. Baggett, 88, Chancery Lane, London.
9,636. Fittings for glow lamps (C.S.). May 4. (I.C. June 25, 1907, Germany.) Siemens-Schuckert-werke G. m. b. H., Queen Anne's Chambers, Broadway, Westminster.
9,654. Miners lamps. May 4. P. M. Justice, 55, Chancery Lane, London. (From Deutsche Gasglühlicht Akt.-Ges. (Auerges.), Germany.)
9,862. Arc lamps. May 6. W. J. Davy, 40, Chancery Lane, London.
9,972. Increasing or decreasing the light of arc or incandescent lamps for theatrical purposes, &c. May 7. L. Sunderland and G. C. Pillinger, 165, Queen Victoria Street, London.
10,098. Filament for glow lamps. May 9. J. W. Ward and R. H. Stevens, 11, Southampton Buildings, London.
10,128. Portable lamps. May 9. J. Bein, 205A, Pentonville Road, London.
10,269. Arc lamp (C.S.). May 12. F. Ruzicka, 115, Cannon Street, London.
10,339. Electrode for arc lamps. May 12. F. M. Lewis, Norfolk House, Norfolk Street, Strand.
10,341. Incandescent lamps. May 12. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From Allgemeine Elektricitäts-Ges., Germany.)

II.—GAS LIGHTING.

8,172. Inverted incandescent lamps. April 13. G. Hands and F. Breeden, 77, Chancery Lane, London.
8,473. Gas pendants (C.S.). April 16. C. W. Kemp, 11, Burlington Chambers, New Street, Birmingham.
8,573. Incandescent burners. April 16. H. R. Prosser, 5, Corporation Street, Birmingham.
8,639. Anti-vibrator for suspended fittings. April 18. S. Jones and A. H. Bennett, 70, Chancery Lane, London.
8,730. Automatic gas-ignition and control (C.S.). April 21. P. Jensen, 77, Chancery Lane, London. (From L. G. Bartlett, U.S.A.)
9,276. Inverted incandescent lamps (C.S.). April 29. M. Graetz, 18, Southampton Buildings, London.
9,286. Nozzles for inverted incandescent burners (C.S.) April 29. (I.C. Nov. 19, 1907, Germany.) Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 1, Great James Street, Bedford Row, London.
9,306. Incandescent mantles (C.S.). April 29. J. Stubbers, 31, Bedford Street, Strand.
9,760. Lighting devices for street lamps, &c. (C.S.). May 5. O. Schubert, 18, Southampton Buildings, London.
9,892. Pressure-controlled igniters (C.S.) May 6. E. Zickwolff, 31, Bedford Street, Strand.
9,907. Anti-vibrators for incandescent lamps. May 7. R. O. Tweedie, 65, Chancery Lane, London.
9,945. Incandescent lighting. May 7. C. Scott-Snell and C. H. Stuart, 25, Victoria Street, Westminster.
9,996. Lighting appliance. May 8. W. Thomson, Royal Institution Laboratory, Manchester.
10,029. Shades or globe-holders for inverted incandescent burners. May 8. A. E. Smithdale, 88, Chancery Lane, London.
10,105. Gas burners. May 9. G. N. Sperryn, 77, Colmore Row, Birmingham.
10,223. Regulating nozzles for inverted incandescent lamps (C.S.). May 11. M. Graetz, 1, Broad Street Buildings, Liverpool Street, London.
10,233. Incandescent mantles (C.S.). May 11. A. Simonini, 332, High Holborn, London.
10,284. Inverted incandescent burners. May 12. E. J. Shaw, 60, Queen Victoria Street, London.
10,295. Gas burners (C.S.). May 12. (I.C. June 3, 1907, U.S.A.), W. O. D. Kelly, 55, Chancery Lane, London.
10,321. Inverted incandescent lamps. May 12. L. Zechnall, 70, Chancery Lane, London.
10,380. Holders for incandescent mantles (C.S.). May 13. J. Bernheimer, A. Gut and A. Melder, 20, High Holborn, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

8,138. Burners for lamps (C.S.). April 13. C. Jahnke and R. Jahnke, 345, St. John Street, London.
8,427. Reflectors for lamps. April 15. F. J. B. Collis, 4, South Street, Finsbury.
8,509. Lighting of billiard tables, &c. April 16. J. H. Faulkner, 111, Hatton Garden, London.
8,565. Automatic acetylene lamps and torches. April 16. E. Grube and A. C. Wells, 7, Southampton Buildings, London.
8,586. Acetylene lamps for cycles, &c. April 18. F. J. Miller, 24, Temple Row, Birmingham.
8,687. Vapour lamp (C.S.). April 21. A. F. Chiesanova, 100, Wellington Street, Glasgow.
9,362. Suspending device for gas, electric, or other lamps. April 30. W. H. Chipperfield, 149, Strand, London.
9,376. Lamps for burning carburetted air, &c. April 30. W. G. Potter, 14, Ingleton Street, Brixton Road, London.
9,971. Inverted vapour burners. May 7. H. Brooper and C. Wilkinson, 1 Broad Street Buildings, Liverpool Street, London.
10,344. Incandescent vapour burners. May 13. F. C. Lynde, 51, Deansgate Arcade, Manchester.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

8,841. Incandescence bodies (C.S.). I.C. April 17, 1906, Germany. Accepted April 23, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
10,513. Arc lamps with laterally supported electrodes (C.S.). I.C. May 5, 1906. Accepted May 13, 1908. H. Beck and Deutsche Beck-Bogenlampen Ges. m. b. H., 231, Strand, London.
10,662. Arc lamp (C.S.). May 7, 1907. Accepted May 13, 1908. C. C. Winther-Hansen and P. Bouchsein, 40, Chancery Lane, London.
12,139. Filaments for lamps. May 25, 1907. Accepted April 29, 1908. F. J. Planchon, 7, Southampton Buildings, London.
13,882. Incandescent lamps. June 15, 1907. Accepted May 6, 1908. T. W. Lowden and The Westinghouse Metal Filament Lamp Co., Ltd., Norfolk Street, Strand.
15,451. Refractory conductors for incandescent lamps. July 4, 1907. Accepted May 13, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
16,503. Attaching tungsten filaments in glow lamps (C.S.). I.C. May 6, 1907, Germany. Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 55, Chancery Lane, London.
16,530. Refractory materials. July 18, 1907. Accepted April 23, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
16,531. Supports for filaments of incandescent lamps. July 18, 1907. Accepted April 29, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
16,956. Arc lamps. July 24, 1907. Accepted April 23, 1908. H. E. Angold and The Maxim Electrical Co., Ltd., 18, Southampton Buildings, London.
19,562. Incandescence lamps having holders or suspenders for the filaments (C.S.). I.C. April 15, 1907, Germany. Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 55, Chancery Lane, London.
21,476. Incandescent lamps with metal filaments (C.S.). Sept. 27, 1907. Accepted April 23, 1908. A. G. Bloxam, Birkbeck Bank Chambers, London. (From Siemens and Halske Akt.-Ges., Germany.)
23,199. Arc lamps (C.S.). I.C. Sept. 4, 1907. Accepted April 29, 1908. D. Timar and K. von Dreger, 7, Southampton Buildings, London.
3,465. Clutch for arc lamps (C.S.). I.C. Feb. 18, 1907, Sweden. Accepted April 23, 1908. L. S. Andersson, 65, Chancery Lane, London.
3,700. Arc apparatus for photography (C.S.) Feb. 18, 1908. Accepted May 13, 1908. J. Schmidt, 31, Bedford Street, Strand. (Addition to 9,574/07.)
8,416. Filaments for incandescent lamps (C.S.). I.C. April 26, 1907, Germany. Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.
9,479. Supporting hooks for lamp filaments (C.S.). I.C. May 3, 1907, Germany. W. Schäffer, 31, Bedford Street, Strand, London.
9,502. Arc lamps (C.S.). I.C. May 2, 1907, Germany. Allgemeine Elektricitäts Ges., 83, Cannon Street, London.

II.—GAS LIGHTING.

9,973. Inverted burners. April 30, 1907. Accepted April 23, 1908. J. H. McLean, F. Phelps, and A. Raybould, 19, Sandon Road, Edgbaston, Birmingham.
14,162. Igniting gas electrically. June 19, 1907. Accepted April 29, 1908. E. Plumstead and Newton & Lawrence, Ltd., 6, Bream's Buildings, Chancery Lane, London.
19,478. Street gas lanterns. Aug. 30, 1907. Accepted May 6, 1908. W. Sugg & Co., Ltd., and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.
20,109. Automatically turning on and off lights from a distance. Sept. 9, 1907. Accepted April 29, 1908. G. Robson, 18, Southampton Buildings, London.
20,153. Inverted incandescent burners. Sept. 10, 1907. Accepted May 13, 1908. A. Turner, Gas Works, Amersham, Bucks.
25,637. Carriers for incandescence mantles (C.S.). I.C. June 13, 1907, Germany. Accepted May 6, 1908. Julius Pintsch Akt.-Ges., Birkbeck Bank Chambers, London.

1,844. Inverted regenerative incandescent lamps (C.S.). Jan. 27, 1908. Accepted May 13, 1908. L. Zechnall and J. Altman, 70, Chancery Lane, London.
2,300. Systems of lighting. (C.S.). Feb. 1, 1908. Accepted May 13, 1908. R. E. Andrews, 37, Oakhurst Grove, East Dulwich, London.
3,785. Filaments for incandescent mantles (C.S.). I.C. Oct. 11, 1907, France. Accepted May 13, 1908. R. Laigle, 6, Lord Street, Liverpool.
4,549. Inverted incandescent lamps (C.S.). I.C. May 1, 1907, Germany. M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.
9,622. Filaments for incandescent mantles (C.S.). May 4, 1908. Accepted May 13, 1908. R. Laigle, 18, Southampton Buildings, London. (Addition to 3785/08.)

III.—MISCELLANEOUS.

(including lighting by unspecified means, and inventions of general applicability).

9,663. Petrol lighting. April 25, 1907. Accepted April 29, 1908. H. Harsant and J. Chalk, Birkbeck Bank Chambers, London.
13,300. Suspending apparatus for lamps for high buildings. June 8, 1907. Accepted May 13, 1908. C. Rees, 20, Hewitt Street, Warrington, Lancs.
23,048. Light modifiers (C.S.). Oct. 18, 1907. Accepted May 13, 1908. F. Monpillard, 111, Hatton Garden, London.
24,871. Vapour lamps (C.S.). Nov. 9, 1907. Accepted May 13, 1908. M. F. P. Oialard Goudon, 111, Hatton Garden, London.
27,022. Oil lamps (C.S.). Dec. 6, 1907. Accepted May 6, 1908. E. R. Schreiber, 111, Hatton Garden London.
3,696. Pendants, &c. (C.S.) Feb. 18, 1908. Accepted May 6, 1908. H. W. Hanwell, 111, Hatton Garden, London.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.—Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

TRADE NOTES.

Messrs. Siemens Bros. inform us that all tantalum lamps are now specially tested previous to delivery, and that in future those which fail prematurely on circuit, owing to faulty workmanship, will be replaced; for this reason, the allowance of 2½ per cent. to cover such failures will be discontinued. This alteration came into force from May 1st onwards. We are also given to understand that the tantalum lamps are now finding extensive use for side-street lighting, the Brighton Corporation having placed an order with the above firm for 15,000 16 c.-p. lamps for this purpose.

The *Sun Electrical Co.* send us a catalogue describing the 'Kalkos' wiring system. Briefly, the system involves the use of tinned brass tubes in place of the iron and steel conduits previously employed, and it is stated that defects due to oxidation and corrosion are thus practically avoided.

Messrs. Moffat & Co. send us a catalogue describing their well-known form of thermopile lamp, a *speciality* of which is the driving of small fan, which in turn drives into the burner the requisite amounts of air and gas, by means of a small electrical current generated by a thermopile.

Messrs. The Union Electrical Co. draw our attention to a list of automatic motor-starting switches both for direct and polyphase currents, and intended for use with motor-driven pumps, air-compressors, &c., which require automatic control when starting.

The *Frister Aktiengesellschaft* (Berlin) draw our attention to the 'Tubus' form of burner, which enables the mantle to be burned in a horizontal position, so that the highest illumination is secured in a downward direction.

Among other matter received, we have also to acknowledge the receipt of a number of well got-up pamphlets relating to the Osram lamps and inverted burners, issued by the *Deutsche Gasglühlicht Aktiengesellschaft*, some interesting particulars of the 'Pharos' inverted gas-lighting system, and a description of the 'Regina' arc lamps, the Weinert lamps, &c.



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The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

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EDITORIAL.

The Annual Meeting of the Institution of Gas Engineers

AND

The International Acetylene Congress.

THE two recent gatherings of the Institute of Gas Engineers and the International Acetylene Congress, furnish gratifying evidence of the tendency towards international co-operation in technical and scientific matters, characteristic of the present century. At the conclusion of the meeting of the English Institution of Gas Engineers many of those present, having accepted the invitation of their German confrères, left London to pay a visit to Berlin. The Acetylene Congress was attended by delegates from all the chief European countries, many speeches being delivered in three languages. As Sir W. Ramsay said at the conclusion of his speech on the opening day, the real value of such meetings lies not so much in the receiving or giving of a certain amount of useful information, as in the opportunity provided to the representatives of different countries of forming friendships and getting to understand each other's point of view.

A number of papers of considerable technical interest were read at both meetings, but we feel that such important meetings as that of the Institution of Gas Engineers might with advantage deal not only with points of technical interest to the engineer, but that the standpoint of the consumer ought likewise to receive attention, and that it would present a favourable opportunity of organizing demonstrations of the most recent methods of gaslighting.

There were, on the other hand, several papers dealing more or less closely with lighting at the Acetylene Congress, notably that of the President, Mr. Bingham, contrasting the merits of acetylene with petrol-air gas. Mr. Bingham, however, dealt with his subject entirely from the acetylene standpoint, and to us it was a matter for regret that in the discussion which followed there was none present to state the case from the point of view of petrol-air gas. As we have re-

peatedly asserted in these columns, those interested in one system of lighting act unwisely in attempting to minimize the merits of another, and ought rather to take every opportunity of hearing what its exponents have to say, in order to learn where their own strength and weakness really lie. Many of the questions raised in Mr. Bingham's paper, which we abstract elsewhere, are of great interest, and we would gladly put our columns at the disposal of such authorities on both illuminants who would like to discuss the matter frankly.

The Effects of different Illuminants on Eyesight.

There was one point raised in Mr. Bingham's paper which seemed to us to illustrate very clearly the want of authoritative and impartial ruling on many vexed questions connected with illumination. We have often called attention to the hopeless discrepancies between the statements of those representing different systems of illumination on this point of eyesight, and insisted upon the need for a thoroughly scientific and impartially conducted investigation, having for its object an authoritative ruling on the disputed points. At present the conflicting statements which greet us on all sides are only ridiculous. We fear that very often the representatives of each system of lighting do not really attempt to discover what is physiologically good or bad in their respective systems of lighting. They merely lay hold of some favourable opinion, or even abstract a convenient passage from it, and proceed to argue that their system is the only one that is physiologically correct and that others are bad for the eyesight.

As an amusing illustration of such conflicting statements, we may mention a few of those which are deliberately put forward in connexion with the gas and electrical companies' exhibits in the Machinery Hall in the Franco-British Exhibition. A visitor passing the gas exhibit is greeted by the advice "save your eyes," in a notice which runs as follows:—

Save Your Eyes.

A WORD ABOUT EYESIGHT.

At the 1905 Congress of the Royal Institute of Public Health *Sir James Crichton Browne* said: "In two generations half the people will be blind and the other half wearing spectacles, unless something is done to check the injury to the eyes."

Dr. Allan Wilson said that "his experience had proved to him that electric light did a large amount of serious harm to the eyes."

The Lancet (Nov. 26, 1904) says: "For some not very clear reason, the incandescent electric lamp seems to be wearying, taxing the muscles of accommodation of the eye, and many people complain that reading by the electric light gives rise to headache."

If you desire to preserve your eyesight and that of your children, you will want the best diffused and softest light, and you will find it best as well as cheapest to *light by gas.*

A few yards further on he comes to the electrical exhibit, and he is then confronted with the following statement, purporting to be extracted from the recent report of the Education Committee of the L.C.C.:—

"With regard to the general efficiency of the two methods of lighting (gas and electricity), there can be no question that electric lighting is preferable to gas in every way. All who have had to do with the lighting of educational institutions are agreed in this matter."

We are also presented with the view of the medical officer to the L.C.C. that "handiness, simplicity, and ease in distributing points of light, complete absence of shadows below the lamp, the possibilities of perfect reflection, healthiness in freedom from consumption of air and production of fumes, and noiselessness, make lighting by the electric glow lamp the most perfect means now available for school use."

There are other equally conflicting statements put forward in connexion with the exhibits to which we refer. Let us, however, imagine the effect of the two quoted above on the average passer-by. It is quite certain that any reasonable person will immediately perceive that no illuminant can be at once notoriously bad for the eyesight and at the same time unquestionably the best for the illumination of educational buildings, in which good illumination, from the physiological point of view, is so essential. The most probable effect of such conflicting statements is

to induce him to believe that there is something radically wrong in both. We think, in fact, that this is just one of those cases in which the public confidence is not gained, but lost, by putting forward sweeping general statements that are certainly not justifiable without further and more detailed explanations.

We can readily believe that brilliant unshaded sources of light, such as the naked metallic filament of an electric glow lamp, for instance, may do harm to the eyes if constantly stared at. But it is quite possible that an incandescent mantle, used in an equally careless way, would also be equally injurious.

It is necessary to distinguish between evils which arise from using sources of light in the wrong way, and evils arising from the quality of light itself. The question of the influence of the quality of light — its "colour" or "spectral composition"—on eyesight demands much careful study before any definite pronouncement can be made.

The Report on the City Lighting.

The report on this subject, and also the letter that Mr. Voysey, the electrical engineer to the City Corporation of London, has sent us for publication in this issue, are of exceptional interest. It is, we need hardly say, very gratifying to us to meet such strong advocacy of the principles for which we have been contending, namely, the desirability of mutual assistance on the part of those representing different systems of illumination, instead of the existing confused and needless hostility. Our views on this subject have been so frequently put forward in this journal as to render repetition unnecessary at the present juncture. We need only express our satisfaction at this new proof of the spread of the growing sympathy which these views are now exciting.

The manner in which this report has been received in the technical press is one more illustration of the necessity for some impartial tribunal to settle these important problems of street-lighting. For how has the publication of this report been regarded in the technical press?

We have before us an electrical journal in which the editorial comments approve Mr. Voysey's decisions, and gleefully point to the portions unfavourable to gas-lighting. We have also a gas journal, in which the contents of the report are subjected to severe criticism, and the decisions at which it arrives are regarded as biassed.

One of our contemporaries also proceeds to draw what seems to us a most unwarranted conclusion from this report when they declare their disbelief in photometrical tests of street-lighting entirely. The results of different observers, they point out, differ among themselves considerably. We ourselves have never been under any false impression as to the degree of accuracy with which such tests are at present carried out. No doubt the tests of different observers do vary; but we can hardly see how this could be otherwise in view of the short time during which serious attempts to measure the illumination in streets have been carried out. We know well enough the difficulty of making measurements at such low orders of illumination as occur under these circumstances, and we also fully admit that our present street-photometers are far from being perfect instruments. But this does not justify the contention that such measurements are useless. Even such as they are, they are vastly preferable to reliance upon mere ocular demonstration and upon the fancy of observers, whose impression as to what constitutes adequate illumination is swayed by many external influences, and is constantly varying.

The difficulties to which our contemporary alludes are inseparable from the origination of any new system of testing, and are in no small measure due to the fact that there has hitherto been no adequate opportunity for the

discussion of the subject. It is for the *principle* of the measurement of illumination that we contend. Once this principle is established, there can be no question that the details of photometrical measurement will soon be settled.

A definite decision upon such important points as the comparative value of flame arcs and high-pressure incandescent gas lights would be extremely valuable. The problem dealt with by Mr. Voysey is one that will constantly recur, and it is safe to say that future tests, carried out under the prevailing conditions, will only lead to conflicting results.

This state of things will continue until a serious attempt is made to organize incontestably impartial tests. Such tests might be carried out *jointly* by representatives of the different systems interested under the superintendence of some impartial expert, who would be present, not for the purpose of prescribing the method employed, but in order to act as arbitrator on any disputed point.

We believe that if the matter was frankly discussed the questions in dispute would prove to be much less serious than is commonly supposed. The details of the method of testing being agreed upon, the experiments would be carried out in the presence of the arbitrator by the two representatives. Any vital difference in their results would soon reveal itself, and the source of uncertainty removed. Neither party could afterwards urge any just ground of complaint against the tests, and we should have gained some reliable knowledge well worth the trouble involved.

From the views expressed in his letter we feel confident that Mr. Voysey would be only too willing to promote the consideration of a scheme of this nature, and we think that our journal, being quite impartial in its outlook, might well be made the medium for a full discussion of the possibility of the plan on the broad lines laid down in this editorial.

There's many a true word—

There is many a true word spoken in jest. Another of our contemporaries has found ground for complaint in the decision of the City Board of Guardians to light the new Homerton workhouse and infirmary with electricity. In this connexion it is remarked, "This would seem to be a good case for the independent 'illuminating engineer,' if there is any field at all for such a specialist."

Now we welcome this paragraph as an illustration that the need for the illuminating engineer is becoming actually felt. Here is a case in which it is felt that an unfair result has been arrived at, but—there is no redress. There is no higher tribunal, whose impartiality is above all question, to whom the matter might be submitted for arbitration. If, as we desire, there were an impartial authority to whom such cases could be referred, all these disputes could be examined, and the prevailing uncertainty as to exactly under which conditions electricity and gas are desirable, and how far the claims put forward on behalf of both illuminants are justifiable, would gradually be removed, and the legitimate spheres of action of both systems of lighting would gradually become recognized. Such cases only emphasize the need of the illuminating expert, whose coming into existence is only a matter of time.

LEON GASTER.

Review of Contents of this Issue.

HAVING shown in the last number how examples of street illumination may be compared by reducing each to a single number representing the mean, **Mr. A. P. Trotter** proceeds to explain his method of expressing the GENERAL ILLUMINATION OVER AN AREA by a CHARACTERISTIC CURVE.

Prof. S. Ruzicka discusses the existing METHODS OF TESTING THE DAYLIGHT ILLUMINATION in educational buildings, and gives the results of his own researches on the connexion between the actual working illumination and the intensity of the brightness of the sky. The value of the ratio between these two quantities constitutes an index as to whether the window space provided under any special circumstances is adequate or no; the method of "relative photometry," which he advocates, consists in comparing the brightness of an artificial sky with the existing illumination due to it, in an exact model of the school-room to be studied. By practical experiment he has found that results so obtained are applicable to actual conditions, provided they are understood to refer to an approximately uniformly bright sky.

E. W. Weinbeer describes a method of very easily and quickly DETERMINING THE MEAN SPHERICAL OR MEAN HEMISPHERICAL CANDLE-POWER of a source from the polar curve of distribution of light. The method is based upon a principle recently described by Kenelly, and consists in the use of a series of movable graduated rules, by means of which the various terms making up the mean spherical c.-p. are automatically added up. The apparatus thus resembles a specially constructed slide-rule, and can be combined with a slide-rule of the ordinary variety for purposes of general calculation.

A report by **Mr. A. A. Voysey,** the engineer of the City Corporation, deals with the LIGHTING OF THE CITY OF LONDON, and describes a series of tests on the illumination of Holborn, Cannon Street, and Queen Street by means of flame arc-lamps and high pressure incandescent mantles. The report is fully illustrated by curves showing the distribution of illumination in the streets named, and contains tables giving exact data as to the conditions under which they were obtained. Mr. Voysey states that the illumination in main streets ought never to be allowed to fall below 0·1 candle-feet, and comes to the conclusion that lighting by flame arc-lamps costs about one fourth of that by gas. He also contributes a letter to our correspondence columns urging the DESIRABILITY OF CO-OPERATION BETWEEN REPRESENTATIVES OF GAS AND ELECTRIC LIGHTING.

Dr. C. V. Drysdale continues his scientific description of various methods of measuring the MECHANICAL EQUIVALENT OF LIGHT AND THE LUMINOUS EFFICIENCY OF ILLUMINANTS by calorimetric and spectrum integration methods.

Mr. W. R. Herring communicates the results of a few additional tests on the GAS LIGHTING AT THE NATIONAL SCOTTISH EXHIBITION which he was unable to include among those published in our last number.

In the SPECIAL SECTION of the present number **W. Biegon von Czudnochowski** contributes a complete description of the various exhibits at the RECENT AUGUR EXHIBITION IN BERLIN. The report includes a description of the methods of lighting and lamps exhibited, representative of both gas and electric lighting, and also discusses their application to shop-window lighting in accordance with the object of the exhibition. Tables of the costs of initial outlay and consumption of energy in the case of the exhibits are given, and the special circumstances to which the different methods are best suited discussed.

In this section some illustrations of the METHOD OF SHOP LIGHTING by gas adopted by MESSRS. EHRICH and GRAETZ and the PHAROSLICHT-GESELLSCHAFT are shown, and the two different methods of lighting briefly

discussed. In the first case the use of concealed lights placed well above the goods in the window is advocated; in the second, the use of high candle-power lamps placed outside the shop window.

Some particulars are also given in this number of the proceedings at the recent meetings of the INSTITUTION OF GAS ENGINEERS and the INTERNATIONAL ACETYLENE CONGRESS. Reference is made to some of the interesting points raised in the speeches of **Sir George Livesey** and the President of the Institute of Gas Engineers, **Mr. Doig Gibb**, and the various papers read before the two societies dealing with matters connected with lighting are abstracted. In this connexion mention may be made of the paper by **Mr. C. Bingham**, who discusses the merits of acetylene and petrol air gas, as regards cost, health, and convenience, from the point of view of acetylene. Other papers before the Acetylene Congress dealt with IMPROVED FORMS OF ACETYLENE BURNERS, the MANUFACTURE OF INCANDESCENT MANTLES intended for use with incandescent acetylene burners and the STATISTICS OF THE RECENT GROWTH OF THE ACETYLENE INDUSTRY in France.

Among other articles of special interest in this number may be mentioned that dealing with the theory of the globe photometer. In a previous number of *The Illuminating Engineer* an article by Dr. L. Bloch described the practical use and applications of this instrument. In the present instance the theory of the photometer is considered in greater detail, the discussion being based upon the contributions of Prof. Ulbricht to the literature of the subject, in conjunction with information specially supplied by him for the purpose of this article.

Among other original articles may be noted those dealing with the PRACTICAL DEMONSTRATIONS OF INTERIOR-LIGHTING recently organized by the GAS LIGHT AND COKE CO., and the PRACTICAL PROBLEMS IN ILLUMINATION presented at meetings of the ILLUMINATING ENGINEERING SOCIETY in the United States.

Two lectures by **Prof. Trouton, F.R.S.**, recently delivered before the Royal Institution, dealt with the development of the theory of light, including the question of the exact nature of light vibrations and the medium in which they are executed. The lecturer dealt specially with the theory of polarization, and showed how light is shed upon the problems involved in the consideration of these phenomena by the analogous behaviour of electro-magnetic waves.

A recent paper by **Dr. Karl Sartori**, read before the Institution of Electrical Engineers in Vienna, deals with the vexed question of the nature of the RADIATION FROM THE NEW METALLIC FILAMENT LAMPS, and the problem of whether their improved radiation from the point of view of light-production is to be ascribed to a higher temperature of incandescence alone. The general impression both of the author and also of **Dr. F. Blau, Prof. A. Grau**, and others who participated in the discussion, favoured the view that the temperature of the metallic filament lamps was really higher than in the case of carbon filament lamps. Dr. Sartori, however, described an experiment which appeared to convey the reverse impression.

A paper was recently read by **Prof. H. Bohle** before the Cape Town Section of the Institution of Electrical Engineers on LIGHTING. The paper is divided into four sections, dealing with GENERAL PRINCIPLES, OUTDOOR AND INDOOR ILLUMINATION, AND ILLUMINATION-PHOTOMETERS respectively. The author discusses the methods of summing up the illumination due to two or more lamps, and discusses a number of practical problems in which the conditions best favouring a certain distribution are to be determined. He also gives a number of general rules governing the degree of illumination requisite for various purposes, winding up with a résumé of the different methods of types of photometers and the globe photometer.

At the end of this number are to be found the usual REVIEW OF CURRENT LITERATURE ON THE SUBJECT OF ILLUMINATION and the PATENT LIST.

TECHNICAL SECTION.

The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 450.)

Characteristic Curves.—The curves which have been illustrated and discussed are of two kinds. The first, which may be called illumination curves, are, as it were, vertical sections along a route, the ordinate being proportional to the illumination on a horizontal plane at any point, and the abscissa being the horizontal distance of that point from the point below the source of light. With the exception of Fig. 14, the candle-power has been assumed to be uniform in all directions. The second, which are sometimes called iso-lux curves, are contour lines of equal illumination, on a horizontal plane. For the simple case of a street or of an open space lighted by a number of similar and regularly spaced lamps, these curves give a good indication of the amount and of the character of the illumination. It is possible to sum up and express by one curve the general distribution of illumination over an area, taking into account lamps of different candle-power and of unsymmetrical or even irregular disposition. This form of curve which by analogy with those used in other branches of science and engineering may be called a characteristic curve, is related to the first of the two kinds which have been discussed. But while in the former case the distribution of illumination along a line, the abscissæ were lengths, the abscissæ of a characteristic curve are areas. A characteristic curve of illumination is a diagram which resembles a steam-indicator diagram in several respects, since the co-ordinates are the measures of an intensity and of an extension respectively, and the area of the diagram is the measure of a power. The maximum and minimum illuminations may be read off at a glance, the true mean may be found by taking the mean of the ordinates, like the mean pressure in a steam-indicator diagram; and the shape of the curve, as in the steam diagram, shows the quality or regularity of distribution. The departure of the curve from a horizontal line shows the want of uniformity of illumination. The portion of an area illuminated to any given degree may be easily found, just as an indicator diagram shows that portion of the stroke during which the steam pressure exceeds any given amount. Luminous flux or total light is (1) candle-power × solid angle, or (2) illumination × area. The area of this diagram is (2), and is a measure of power in an optical form. Such diagrams might be used for a number of other

statistical purposes, such as the distribution of population.

Taking the simplest possible case, viz., a single lamp emitting uniformly in all directions light received on a horizontal plane, the illumination curve being of the type shown in Figs. 9 (p. 185) and 26 (p. 448); a minimum illumination or a circle of any given radius being chosen, the characteristic curve may be drawn by plotting areas as abscissæ, and the illumination in foot-candles or lux on those areas as ordinates. From Table 1, p. 185, it is seen that with unit illumination AB (Fig. 33) at the centre of the circle, an illumination of 0·9 is found at

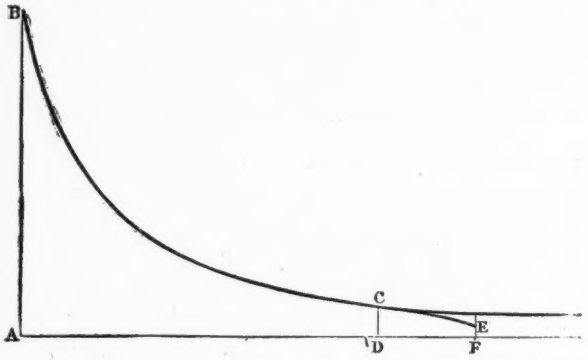


FIG. 33.

radius 0·270, that is, within a circle of area 0·228; an illumination of 0.8, at radius 0·401, or within a circle of area 0·505. Such illuminations and areas give the curve BC Fig. 33 as far as C, the last ordinate being 0·1, and the abscissa 11·4, being the area of a circle of radius 1·907. This curve differs from the cosine cubed curve Fig. 9 only in the horizontal scale, the former being the square of the latter, but reduced to a convenient length. The first part of the curve becomes, as it were, shrivelled up, and the flat top seen in Figs. 9 and 25 is imperceptible.*

If instead of a circular area a square one be chosen, the extremity of the characteristic curve becomes modified. Let a square be circumscribed round the circular area, as in Fig. 34. The parts of the square beyond the circle diminish in illumination, but diminish more rapidly in area as their distance from the centre increases. The limiting illumination is found to be 0·04, and the remainder of the curve has been calculated, and is represented by CE, Fig. 33.

A characteristic curve is an illumination curve with a transformed scale of ordinates. The areas are conveniently represented as percentages on a decimally divided scale. Let BD, Fig. 35, be an illumination curve plotted to any scale on the radius AC, the maximum illumination, and at the distance AC, let AD be the minimum. Produce BA to E, making AE any convenient length. Draw CF parallel and equal to AE. Divide AC into any convenient number of equal parts, and CF into the same number of equal parts. Draw radial lines from A to each of the dividing points on CF. For example, AG. Through the corresponding point H in AC draw a perpendicular KH, and produce it to intersect AG. Through the intersection draw a horizontal line cutting AE at L and produce it to M, making ML equal to KH. The curve running through such points as M is the characteristic curve of the illumination curve BD, for a circular area of radius AC.

The intersections of the radial lines with the perpendiculars lie on a parabola or curve of squares, this being one of the well-known methods of draw-

* If the base of Fig. 9 is bent to fit a parabola and viewed from a distance, the curve would appear identical with Fig. 33.

ing a parabola. Lengths on AE are proportional to π times the squares of corresponding lengths on AC, since AE is a scale of areas of circles, and AC is a scale of radii of those circles. To find the mean ordinate of a curve, the usual procedure is to draw ten ordinates at 5, 15, 25, &c., up to 95 per cent. of the length of the base, to add

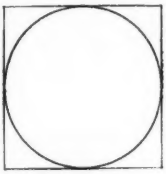


FIG. 34.

their lengths and divide by 10. These ordinates may be drawn directly on the illumination curve. Let the length of the base or extreme radius of the illumination curve Fig. 36 be R, then $r = \sqrt{\frac{R^2 \times d}{100}}$ when r is the radius or the abscissa on the illumination curve of an ordinate, and d the precentage of the total area. Thus the 5 per cent. ordinate is at 1·34, the 15 per cent. ordinate at 2·32, and so on, as in Fig. 36.

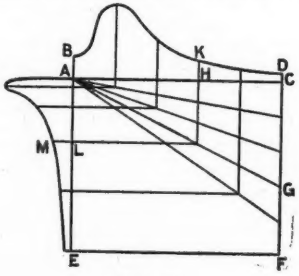


FIG. 35.

To carry out this calculation on a slide rule let R be 6, set the 10 on the C scale over 6 on the D scale, and below 5 and 15, &c., on the B scale, find 1·34 and 2·32, &c., on the D scale. This brings out a point of considerable practical interest, that the illumination near the lamp is of very little importance, for it is spread over a very small area.

The characteristic curves in Fig. 37 are derived from the curves in Figs. 10, 11, 12, and 13, both the maximum illumination and the minimum area being reduced to one hundred.

These characteristics do not strictly represent the distribution of illumination over a large area illuminated by lamps in rows, since there are several different ways in which such lamps

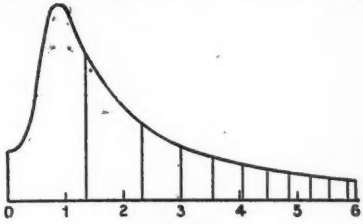


FIG. 36.

may be arranged, viz., quadrilaterally, as at the corners of the squares on a chess-board; quincuncially, as at the centres of squares of one colour on a chess-board; or hexagonally, as the cells of a honeycomb. The characteristic of a hexagon differs but little from that of a circle, the lamp in each

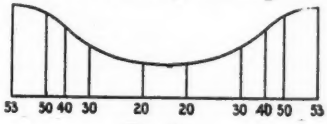


FIG. 39.

case being over the centre. The variations of illumination represented in Fig. 37 are simply those of the resultant curves in Figs. 10 to 13, and the areas are supposed to be circular.

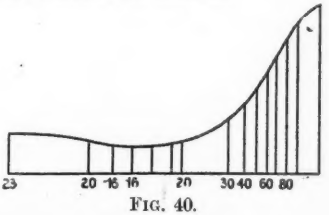


FIG. 40.

Fig. 38 is a portion of Fig. 19 (p. 360), and presents some of the features of lighting by lamps on alternate sides of a street. It differs from a practical case by the closeness of the lamps in proportion to the width of the street, and by the uniform candle-power of the lights in all directions.

This example is, perhaps, more suitable than a practical one for showing the difference between the true mean illumination and the average taken along a line, since the quantities may be easily calculated. The difference is much less than in the case of a single lamp, as already discussed (p. 449).

The former never reaches the maximum, and the latter is very different from the illumination curve due to two lamps at a distance apart equal to $7\frac{1}{2}$ times their height (see Fig. 13) by

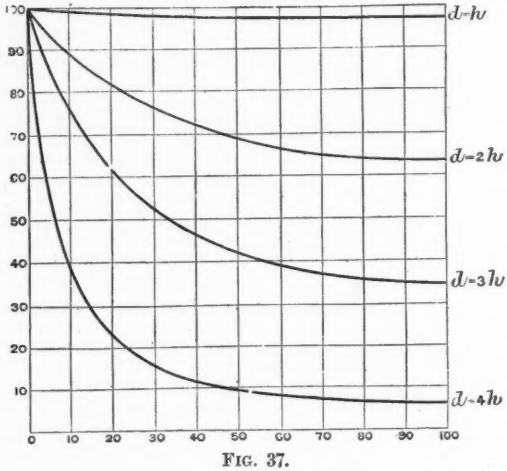


FIG. 37.



FIG. 38.

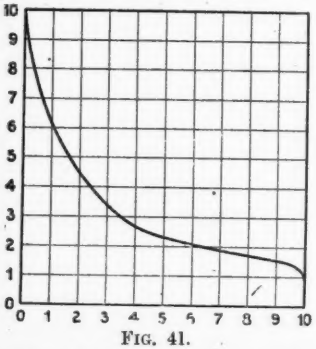


FIG. 41.

Fig. 39 is the illumination curve along the middle of the street, and Fig. 40 is the curve for a line parallel to this, passing through the alternate lamps. reason of the light of the alternate lamp on the other side of the street.

The mean ordinate of Fig. 39 is 33; the mean of Fig. 40 is 34·15. The characteristic curve is given in Fig. 41. The areas of each contour were measured and plotted against the illumination. This is necessarily the method of finding the characteristic curve from a set of photometric tests forming a photometric survey of an area.

The mean ordinate of this diagram gives the true mean illumination 29·8. As might be expected, the mean taken along a line through the lamps is the highest. The difference would be greater if the lamps were more widely spaced. The droop of the curve towards the minimum appears here as in the portion CE of Fig. 33.

(To be continued.)

The Provision of Adequate Daylight Illumination in Schoolrooms.

By Dr. Stanislav Ruzicka,

Professor of Hygiene in the Bohemian University, Prague.

The problem of providing adequate daylight-illumination is one of the most difficult in school hygiene. There are so many different factors to be borne in mind, while even the source of light itself—the sky—varies very greatly in intensity from time to time.

I myself have made measurements of the brightness of the sky at zenith, extending over many months, and carried out between nine o'clock in the morning and three in the afternoon. As a result the brightness (leaving out of account times of exceptional darkness) was found to fluctuate between about 2,000 to 8,000 candle-metres.

As a result of a series of tests undertaken at Prague during these seasons, I have fixed the minimum sky-intensity at zenith likely to occur at 2,000 candle-metres. This excludes the month of December, the darkest month in the year, but during the greater part of this time schoolrooms will be unoccupied, owing to the Christmas vacation.

The problem with which we are confronted may now be stated as follows: namely, to design school-buildings in such a way that *even in the darkest part of the room a minimum permissible illumination of* 20 *lux, corresponding to a sky-intensity of* 2,000, *is available.* In fact, we may specify that the minimum available illumination is to be 1 per cent. of the "sky-intensity." This fraction may be looked upon as constant, and specially applicable to illumination from a roughly uniformly brilliant sky; this condition, moreover, is most nearly realized just on those dark and cloudy days with which we are concerned.

Let us now consider the various conditions on which the admission of daylight from the sky depends. The construction and position of windows, the distance away and height of adjacent buildings, and the amount of light they reflect, the position of the desks and tables in a schoolroom, the colour of the walls and ceilings, the number of students present—all these are very important factors, which I have recently considered in detail.*

One of the simplest attempts to secure conditions favourable to good daylight-illumination consists in specifying the *window-space required for a given floor-area.* This system, however, would evidently yield the same result for a room on the ground floor as for one at the top of the building; and similarly a schoolhouse situated in a narrow street would be specified, just as if it were as well illuminated as another standing in its own grounds. Then, again, the method takes no account of the nature of the interior, the position of the windows, the colour of the walls, &c.

The method of specifying of the *angle of opening* (Offnungswinkel) *of the window,* in conjunction with the *minimum angle at which light can enter a room,* is more complete in so far as it takes account of the height of the buildings opposite, the height of the windows, and the distance away of workers from these windows. On the other hand, it ignores such important factors as the *number* and *breadth* of the windows, and the reflecting power of the walls and ceilings within the room.

The specification of *the solid angle subtended by the visible sky-area* (the "Raumwinkel" of Weber) takes into account all the above factors, with the exception of effects of reflection from walls, ceilings, and other objects within the room.

How influential such reflection may be in promoting good illumination can be judged from the fact, to which I

* See 'Die relative Photometrie,' *Archiv. f. Hygiene,* 1907.

recently drew attention,* that it is possible sufficiently to illuminate a room *by reflection alone*, when the brightness of the sky is 2,000 units.

I am, however, convinced that it is impossible to devise a mathematical formula connecting working illumination and the brightness of the sky, taking account of all the factors influencing the access of light to a workroom, which would be of any rare practical value. It is, therefore, far preferable to study the connexion between these two quantities by means of actual measurement. On this principle is based my system of '*Relative Photometry*,' in which the brightness of the sky at zenith is compared with the actual existing illumination, and allowance for the influence of the many complex factors entering into the problem is rendered unnecessary by *observation of their total ultimate effect*.

The practical value of this relation,

$$\frac{\text{working illumination}}{\text{sky-intensity}}$$

lies in the fact that it at once enables us to calculate what the actual value of the illumination in a workroom will be under the most unfavourable daylight conditions, *i.e.*, a sky-intensity in the neighbourhood of 2,000.

The process of determining this relation is carried out as follows: a complete model, to scale, of the ground floor schoolroom to be studied is constructed, the benches, windows, &c., being shown in their actual positions; small pieces of white paper are attached to the benches in regions where the illumination is to be examined. The front wall of this schoolroom may take the form of a hinged board of convenient size.

This model is entirely enclosed within a second much larger box, the upper surface of which consists of a semi-transparent sheet of white paper placed between two glass plates; this, when illuminated, serves as an "artificial sky." The side of this box facing the model represents the front of a building supposed to be opposite the schoolroom windows, on the other side of the street. The bottom of the box represents the level of the street and ground floor. The inner surfaces of the two sides of the large box, on either side of the model, consist of mirrors, and have thus the optical effect of lengthening the artificial sky so as to reproduce the conditions occurring in a long street. The remaining side of the large box, that *behind* the model, is removed and replaced by a black cloth. The interior of the box is thus illuminated only by the light from the artificial horizon.

Before proceeding to make observations, the experimenter stands the whole arrangement on a table in some open place to which daylight has free access. He then puts his head and shoulders into the box, drawing the black cloth tight in order to keep out stray light, places the "relative photometer" on the ceiling of the model, and compares the illumination in the model schoolroom with the brightness of the artificial sky. In order to render this possible, apertures are made in the ceiling of the model just above the test-pieces of white paper on the benches, &c.

The relative photometer—shown diagrammatically in Fig. 1—consists essentially of a Lummer-Brodhun prism, the central mirror-field, m, of which reflects to the eye of the observer an image of the test-pieces of paper placed above the benches.

The outer portion of the field of view is illuminated by light from the artificial horizontal reflected, as shown, by means of the mirror M. The observer would therefore see the image of the test-paper as a central darker spot on the image of the artificial sky. Between M and m is placed a wedge of smoked glass W, consisting of two portions which may be slid over each other, thus varying the thickness of the wedge as a whole, and therefore obscuring to a greater or less degree the light passing through it.

By adjusting the thickness of this wedge the observer can render both portions of the field of view equally bright, and it is evident the value of the thickness that must be introduced furnishes an indication of the ratio

* Casopis lékaru ceskych, 1907. *Archiv. f. Hygiene*, vol. 63.

of the brightness of the two sources considered.

The question may be raised how far measurements executed in this way correspond to natural conditions. I have shown (*loc. cit.*) mathematically that the actual *height* of the "sky" or clouds, above the ground, did not influence the resultant intensity of illumination, provided the *brightness* remained constant. It was found further that the very much brighter natural sky might be substituted for the artificial one without materially affecting the results; the ratio,

$$\frac{\text{working illumination}}{\text{brightness of sky}}$$

remained the same, though naturally the absolute intensities were very much higher. Both, however, seemed to increase in the same proportion.

a certain minimum illumination, *even on the darkest days that can occur.*

The method of "Relative Photometry," as outlined above, can be very advantageously and conveniently applied to the predetermination of the daylight-illumination in schools yet to be built. In such a case we construct a model of the proposed schoolroom, and, as a result, of our experiments, contrive such alterations in the window-space, the scheme of decoration in the interior, &c., as may be necessary to ensure the required conditions. The effect of altering all the factors involved can be studied in the model, and we can take measures to secure beforehand that the illuminator in the schoolroom, when erected, will be satisfactory.

Moreover, measurements can be

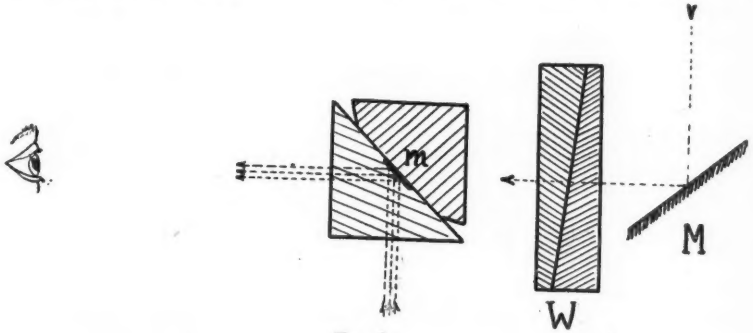


FIG. 1.

Yet it is not really advisable to use the natural sky for this purpose, because, as explained previously, its occasional lack of uniformity in brightness is prejudicial to the accuracy of this method of testing. Nevertheless, we are justified in basing our method on the *uniformly* bright sky for two reasons: firstly, because we obtain a better *average* result by so doing, and secondly, because we are mainly concerned with the least favourable conditions prevalent in the darkest season of the year. Under these conditions we usually observe that the sky presents a very nearly uniformly bright appearance all over. We are, therefore, utilizing just those conditions as are justified by our desire to secure

carried out in a much more economical manner by the use of such models, because the study of the conditions of all the schools in a district can be put into the hands of a single expert, who can make the necessary experiments in his office, and decide on what alterations are required, without it being necessary for him to be continually travelling about to observe the effect of each small modification he introduces. And, lastly, such an expert would have at his command a means of trying experiments on a small scale, and actually observing the result, instead of being obliged to make costly alterations, which may, after all, afterwards fail to achieve exactly what was needed.

The Production and Utilization of Light.

Luminous Efficiency and the Mechanical Equivalent of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 462.)

Direct Measurement of the Mechanical Equivalent of Light.—The most direct mode of procedure is obviously to allow a beam of light of any required quality to full simultaneously on some form of radiometer and a photometer, and to compare the indication of the radiometer with that obtained from a known source of radiation at a given distance. As nearly all devices for measuring low intensities of radiation are liable to troublesome variations, it is of the greatest importance that the comparison between the radiation in the beam under test and the known radiation should be effected as quickly and easily as possible, and with the minimum of disturbance.

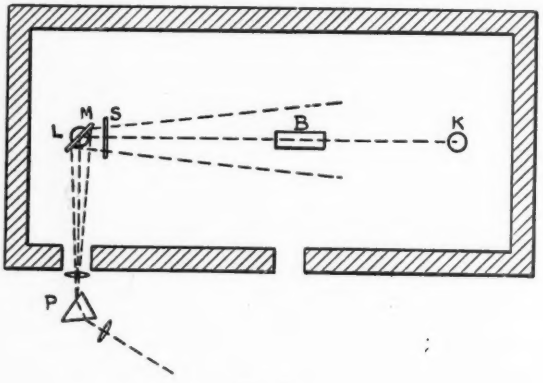


Fig. 5.

Figs. 5 and 6 show the arrangement. of apparatus adopted after consideration of the above points. A small intense source of light, such as an arc or Nernst filament, was employed, in conjunction with a lens and carbon bisulphide prism P, to form an approximately pure spectrum at the photometer and radiometer box B. By using a narrow slit an approximately monochromatic light of any required wave-length could be projected on to the photometer, while by widening the slit a band of any width up to the entire limits of the visible spectrum could be employed, the integration being automatically performed without any other collecting device. The known source of radiation consisted of a glow-lamp, which will be referred to as the "comparison lamp" L, placed close to the prism (in some cases beneath it so that both were approximately on the axis of the bench). A standard glow-lamp K was kept continuously burning on the other side of the photometer box B. A fixed screen with an aperture served to block off all radiation but that from the prism P or comparison lamp L, while a sliding metal screen S, actuated by a cord, could be rapidly moved in front of one or the other. In taking the readings the light from the prism was allowed to fall on the

radiometer, and the current through the comparison lamp varied until on moving the screen S in front of P or L alternately, no change could be noticed. In this way all disturbances due to external changes of temperature could be eliminated, and the observations were much more rapidly obtained than by waiting for slow deflections.

A glow-lamp was used as the standard source of radiation for the following reasons: (*a*) the total power is easily measured by the P.D. and current, the possibility of errors due to selective absorption in the radiometric device. Further, by enclosing the source in a vessel of relatively large size from which the air has been withdrawn, convection is still further reduced, owing to the low temperature of the walls of the vessel. These two conditions are well satisfied in the glow-lamp, and make it immeasurably superior to low temperature sources such as employed by Thomsen and others. On the other hand, the radiation is not uniformly

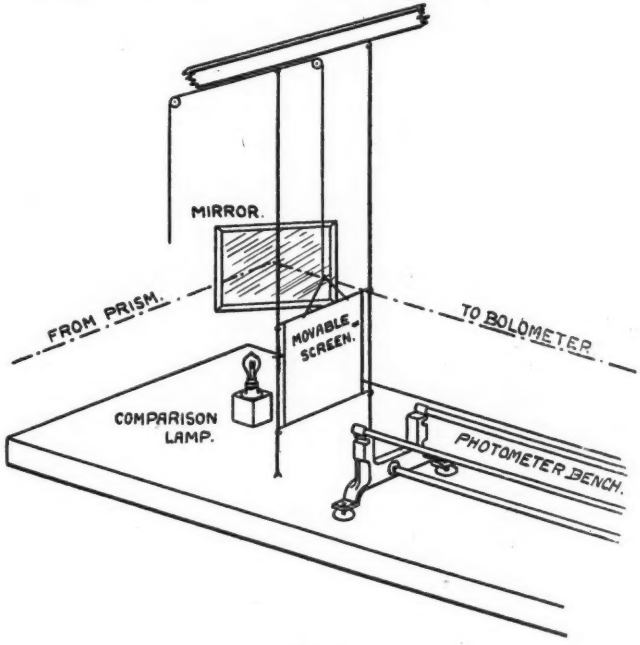


FIG. 6.

and can be readily regulated; (*b*) the ratio of convection and conduction to radiation is very small. Since by the Stefan Boltzmann law the radiation is proportional to $(T^4—T_0^4)$, while according to Dulong and Petit the convection is proportional to $(T—T_0)^{1\cdot235}$, it follows that the ratio of radiation to convection increases very rapidly with the temperature. It is also of advantage for the dominant wave length of the comparison source to approach as nearly as possible to that of the light tested, in order to eliminate distributed. But this difficulty can be overcome by remembering that the dominant wave-length is a function of the temperature, and that for a red-hot filament at a temperature of from 700 to 1000 degrees Centigrade we have by Wien's law $I_\lambda = C_1 \lambda^{-5} \epsilon^{-\frac{C_2}{\lambda T}}$, Paschen and Wanner find 14,440 as the value of C_2 in this expression, from which by differentiation the dominant wave length $\lambda \max = \frac{2888}{T.}$

Hence for temperatures in the neighbourhood of 1,000 degrees absolute λ max is of the order of 3μ, which is negligible in comparison with the dimensions of the filament. We are

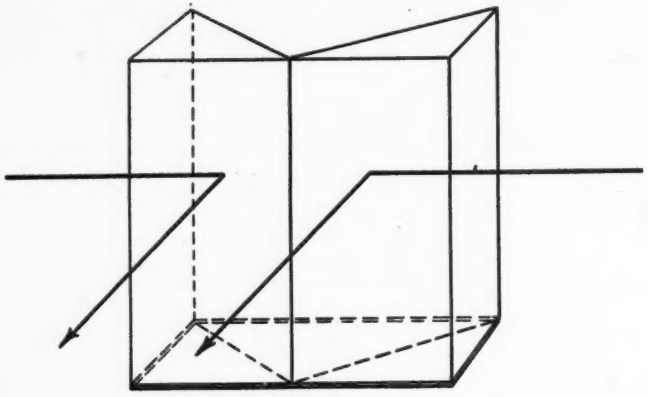


FIG. 7.

therefore justified in assuming that the distribution of radiation will be similar to that of light, and this can be determined once for all by the photometer, giving us the relation of the intensity in any given direction to the mean spherical emission.

The photometer employed was of a special form, devised by the writer

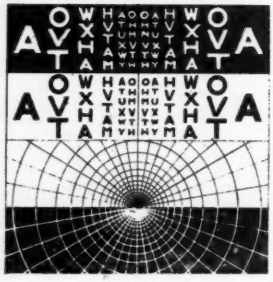


FIG. 8.

for ordinary and heterochromatic measurement. It consists simply of two totally reflecting right-angled prisms, mounted with their edges in contact, as shown in Fig. 7. When this combination is set up between two lamps, the light from each is reflected—as shown—and can be received on a screen placed in contact with the front face of the prism. This screen may be simply of translucent paper or opal glass, in which case the appearance is identical with that of the Joly paraffin block photometer; or in the form of a discrimination diagram, which serves for heterochromatic work. The diagram actually employed is shown in Fig. 8. The advantages of this arrangement are, briefly, that it serves either for isochromatic or heterochromatic photometry; it is absolutely symmetrical; it is not affected, as are the wedge photometers, by a slight inclination to the axis of the photometer bench; it forms a very sensitive cross staff for indicating whether the lamps and the photometer are in line, and whether there is any inclination to the axis; and, lastly, it permits any portion of a spectrum to be brought exactly to the dividing line, so that the comparison may be made with a fairly short spectrum on one side.

For the measurement of the energy a pair of thermo junctions on the lines employed by Prof. Fery was at first made up, but was found insufficiently sensitive. They were therefore replaced by a bolometer, which was made of 50 cm. of 2 mil copper wire wound backwards and forwards on a mica frame, and had a resistance of about 7·5 ohms. Two such bolometers were made and mounted in the same case with the photometer prisms, as shown

in Fig. 9, the centre of the bolometer being carefully adjusted to be over the edge of the prisms, so as to be in the part of the spectrum under photometric examination. To protect the bolometers from draughts the two ends of the box and the observing window were covered with quarter-wave mica sheets.* The two bolometers were separated by an asbestos screen, and were connected to three terminals on the top of the box, whence three flexible conductors were taken to a Carey Foster bridge and connected, as in Fig. 10, thus enabling balance to be conveniently obtained. By having the two bolometers, changes of the air temperature are of less importance, and the whole photometric and radiometric arrangement is reversible. The ratio coils were of 10 ohms each, and a moving coil galvanometer, having a resistance of 7·5 ohms and a sensitiveness of 22mm. per microvolt, was employed. The current in each of the bolometer grids was from ·04 to ·1 ampere.

In taking the readings the photometer head was first fixed in the middle of the bench, and the spectrum moved until the required colour appeared at the dividing edge between the prisms. The standard lamp was then brought up and balance obtained at a distance d from the photometer. Next, the comparison lamp was regulated, as above indicated, until the heat balance was obtained, the comparison lamp being at a distance D, and supplied with power W watts. Then, on the assumption that the heat from the comparison lamp was radiated equally in all directions, we have :—

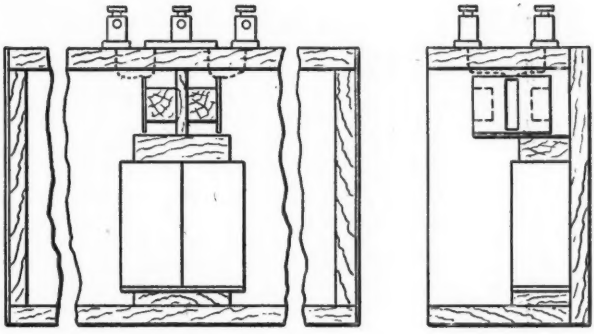


Fig. 9.

Intensity of radiation at bolometer $P = \frac{W}{4\pi D^2}$ watts per square cm.

Intensity of illumination of beam $I = \frac{K}{d^2}$, where K is the candle-power of the standard lamp.

Hence the mechanical equivalent of light $M = \frac{4\pi P}{I} = \frac{W}{K}\left(\frac{d}{D}\right)^2$, or if f is the ratio of the mean spherical candle-power to the candle-power in the working direction for the comparison lamp, and r the ratio of radiation to total power, $M = \frac{Wr}{Kf}\left(\frac{d}{D}\right)^2$, giving the mechanical equivalent in watts per candle.

A careful determination of the candle-power of the comparison lamp in various directions when kept at a constant P.D. was made by Mr. Jolley, resulting in a ratio of $\frac{\text{M.S.C.P.}}{\text{M.H.C.P.}}$ or

* Tests were afterwards made to see if these mica windows had any influence on the result, by interposing several such films, but no perceptible effect was noticeable.

spherical reduction factor of ·862, agreeing very well with the ·865 given by Paterson, and of a ratio of the M.S.C.-P. to the candle-power in the direction in which the radiation was taken, of ·78, which is accordingly the value of the factor f.

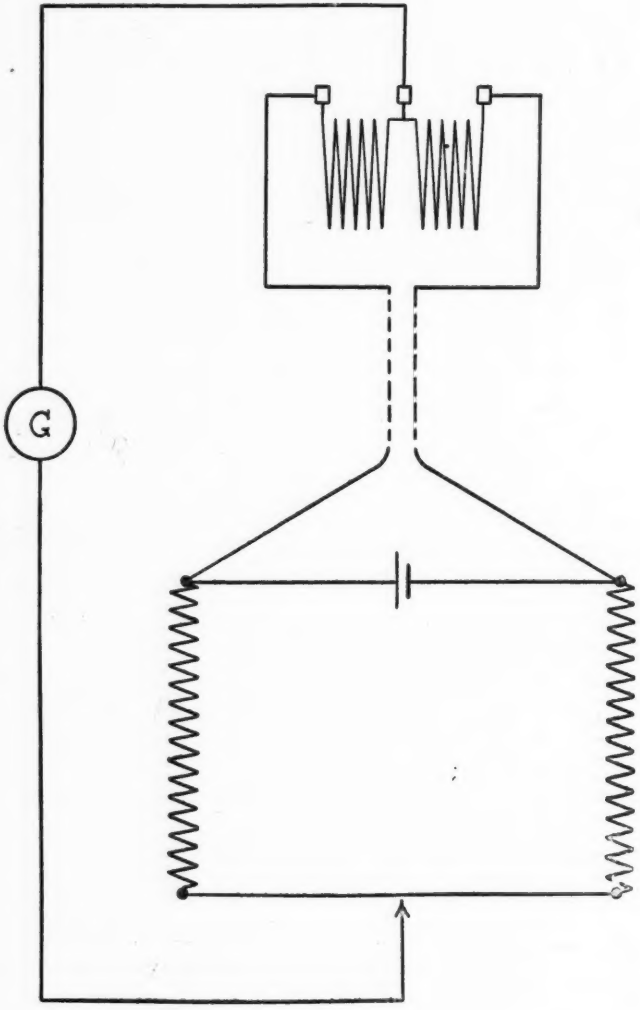


Fig. 10.

(To be continued.)

The Fifth International Acetylene Congress.

(With which is incorporated the Fourth Meeting of the International Committee for Acetylene and Calcium Carbide, and the Seventh Annual Meeting of the British Acetylene Association.)

THE FIFTH INTERNATIONAL ACETYLENE CONGRESS was held in London on May 28th, 29th, and 30th, and afforded an excellent example of the tendency towards internationalization in trade and science. Many foreign delegates were present, and the International Committee of Organization included representatives from Austria-Hungary, Belgium, Canada, Denmark, France, Germany, Great Britain, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, and the United States.

The opening speech on the first day was given by **Sir Wm. Ramsay**, the technical portion of whose remarks dealt mainly with the chemistry of processes for the manufacture of calcium carbide, and their historical development. In conclusion Sir Wm. Ramsay extended a hearty welcome to the foreign delegates, and declared that, in his opinion, the chief value of such a congress lay in the formation of friendships and the social intercourse they rendered possible, rather than the mere receiving of certain items of information.

The remaining part of the day was occupied in the reading and discussion of papers, and in visits to various acetylene establishments in Victoria Street.

On Friday the annual meeting of the Acetylene Association took place. After the preliminary business had been settled an address was given by the President (**Mr. F. S. Thorne**), who referred in general terms to the progress that was still being made in the manufacture of acetylene for purposes of illumination. One direction in which he looked for still greater progress in the future was the design of incandescent acetylene burners.

On this and the third day of the Congress there were further papers and demonstrations, and a number of items of interest to the visitors were arranged. These included the official dinner at the Trocadero Restaurant, a motor-car trip to the residence of the President, and visits to the Crystal Palace and the Franco-British Exhibition. The next Congress is to take place in Vienna in 1910.

Among the various papers read at the meetings dealing with the "illuminating" side of the acetylene industry, mention must first be made of the paper by **Mr. Charles Bingham,** entitled 'Acetylene and Petrol-Air Gas.' These two illuminants must be regarded as rivals in those circumstances in which neither electricity nor gas-supply is available, and a self-contained plant is essential. Mr. Bingham attempted to demonstrate that "Acetylene is cheaper, safer, healthier, more convenient, and more ornamental than the petrol-vapour light."

The "cheapness" of a variety of illuminant, he said, calls for careful study. A light may appear cheap in the laboratory, or in the saleroom; but the only test on which reliance can be placed is actual experience in practice, in a country house or railway station, for instance. The cost of such system of lighting may be divided into—

(*a*) *Initial costs* of installation, including (1) The gas-making plant itself, (2) the piping, (3) the burners, (4) the fittings (wall-brackets, pendants, &c.), and (*b*) *Running cost.*

It was not, the author explained, easy to make absolutely accurate comparisons between the two systems, but he thought that the following

details might be regarded as representative :—

PETROL GAS.

	20 Lights			40 Lights			80 Lights		
	£	s.	d.	£	s.	d.	£	s.	d.
Litz Co.	40	0	0	50	0	0	80	0	0
National Co. ...	45	0	0	60	0	0	110	0	0
	20 Lights			50 Lights			70 Lights		
Non-Explosive Gas Co.... ...	26	5	0	57	15	0	78	15	0
De Laitte... ...	48	10	0	70	0	0	90	0	0

ACETYLENE.

	20 Lights			40 Lights			80 Lights		
	£	s.	d.	£	s.	d.	£	s.	d.
Clapham	22	0	0	31	7	6	42	15	0
Manchester Acetylene Gas Co. ...	19	7	0	28	14	0	42	8	0
Standard Co. ...	23	0	0	40	0	0	65	0	0
Thorn & Hoddle...	21	5	0	25	0	0	32	0	0

As regards the cost for piping, the author claimed that, as petrol-gas had a much lower heating and illuminating power than acetylene, very much more of it must be burnt. This necessitated very much larger pipes, which not only cost more in themselves, but involved pulling about walls, floors, &c., to a greater extent. On the other hand, the pipes for acetylene were so small that it was often possible to place them on the wall of a finished house, without interfering with the wall-paper or wainscotting; this was rarely feasible with petrol-gas pipes, their large size rendering them unsightly.

The cost for petrol gas burners he stated to be as follows, including a single mantle: Litz, 3*s*. 2½*d*. to 4*s*. 1½*d*.; National, 4*s*. 3*d*. to 6*s*. 6*d*.; De Laitte, 2*s*. 8*d*. to 5*s*. 3*d*. The cost of the best acetylene burners was about 10*d*. to 1*s*. each.

Lastly, there was the question of the fittings (wall brackets, pendants, &c.) to be considered, and the author thought that this would come out about the same in both cases.

Finally, he suggested that the capital outlay for petrol gas is at least 50 per cent. more than for acetylene.

The author then proceeded to quote a number of cases in which it appeared that the running costs of acetylene-lighting had proved lower than petrol-air gas, assuming that mantles cost 6*d*. each, carbide 15*l*. a ton, and petrol 15*s*. a gallon.

He also proceeded to cite the instance of a British railway, a company working more than 2,000 miles of line, who for the last two years had made comparative tests at various stations; as a result, the engineer reported to his Board that in actual practice petrol gas was equivalent to coal gas at 3*s*. 6*d*. per 1,000 cubic feet, while acetylene was equivalent to coal gas at 2*s*. 6*d*. Thus the cost for petrol gas works out in actual practice at 40 per cent. more than acetylene.

In all the above comparisons the light given by ordinary open-flame acetylene burners was compared with incandescent petrol gas burners. If the acetylene incandescent burners now rapidly coming into use be taken as basis, the author stated that the comparison becomes infinitely more to the disadvantage of petrol gas.

SAFETY.

This part of the question may be divided into three heads, viz.: (*a*) safety in the dwelling; (*b*) safety in the gas house; and (*c*) storage of the raw material.

As regards (*a*); where the petrol is led into the house in the form of a very weak vapour there is practically no difference between petrol gas and acetylene. The author knew of no record in this or other countries of any explosion caused in a house by the escape of petrol-air gas or acetylene from the burners or from a leak in the piping.

Where, however, as is the case in some systems, the petrol itself passed into the house *in liquid form* in pipes, or was stored in a vessel near the light, there was always a very serious danger, and in this form petrol, or gasoline, as it is called in America, was, according to the statistics issued by the American Fire Insurance Companies, the most dangerous of all ordinary illuminants.

As regards the gas-generating plant

(the gas house), it sufficed to state that fire insurance companies would insure an acetylene gas house, but they would not insure a petrol gas house.

Lastly, there was the question of the raw material itself. Carbide in hundreds of cases, has been taken out of factories when these were burning, without any explosion occurring, and the author was not aware of any case on record of a fire being caused by the storage of carbide or the charging of an acetylene generator.

On the other hand, cases were on record of the vapour from a leaky petrol vessel being ignited at a distance of many feet by a chance light.

Reference may also be made to the French *Revue des Eclairages* (*Lighting Review*) of January 15th, 1908, in which a record is given of the accidents caused by the various systems of lighting in the single month of December, 1907, showing: caused by coal gas, 11 accidents; caused by petroleum, 19 accidents; caused by acetylene 2 accidents; caused by petrol 37 accidents; caused by alcohol, 8 accidents In spite, therefore, of the infinitely smaller number of lights in use, petrol caused almost as many accidents as all its rivals put together.

HEALTH.

This part of the subject might be divided into two chief heads: (*a*) effect on the eyesight; (*b*) effect on the atmosphere of the room.

As regards (*a*); the supposed candle-power of a light had little to do with its value because all lights are composed of rays of different colour. Some of these rays were useful; some useless; some, if anything, harmful. Now, the acetylene flame contained a far larger proportion of useful rays than the incandescent light used with petrol gas.

According to Vidal, the ordinary acetylene flat flame had more than three and a half times the actinic value —candle for candle—of the Welsbach incandescent light. In this connexion the author quoted the opinion of Mr. E. F. Robson, Consulting Architect to the Local Government Board, who had publicly stated that, after an experience of twenty years, he places acetylene at the head of all lights for schools, because it is the best light for the eyesight.

Turning to point (*b*); great stress is laid by air-gas advocates on the fact that their gas contains so much air that no additional oxygen is taken from the air of the room.

The author, however, considered that there was very little to choose between the two systems, as far as consumption of oxygen and production of carbonic acid are concerned. According to his experiments, a full-size petrol gas-burner removed about two feet of oxygen from the air per hour, and produced about 1¾ feet of carbon dioxide, while, for a three-quarter foot acetylene burner the figures were almost exactly the same. From the point of view of pollution of the atmosphere both systems were far and away ahead of petroleum lamps, candles, and flat-flame coal-gas burners, but from the point of view of the oculist acetylene was far ahead of all other artificial illuminants.

CONVENIENCE.

Here again acetylene outstripped its rival. Indeed, it might fairly be said that in one respect only does petrol gas excel; it was undoubtedly a little easier to fill a vessel with a liquid like petrol than to fill the trays of an acetylene generator with carbide and remove the sludge.

In point of time, however, the difference was not very great, and if the regulations now enforced in Germany (*i.e.*, that the petrol shall be pumped, not poured, into the apparatus, and that the apparatus shall be separated from the petrol tank by a wall) should come into use in this country also, this small advantage would disappear.

There were, however, many other disadvantages accompanying petrol gas which did not exist with acetylene.

For one thing, petrol gas not being a true gas (but merely air more or less saturated with petrol vapour), was liable to return to the liquid form just as easily as it vaporized.

Owing to the tendency of petrol gas to condense, it was not possible to carry pipes downwards; for instance, an underground pipe could not be carried from the house to an outhouse or stable unless the generating plant were placed on a lower level than the lowest point in the piping. In one case a petrol gas firm had proposed to put in three different generating plants, as being the only satisfactory way of lighting a house with two blocks of stables. The order was, therefore, given to an acetylene firm. Again, if the length of piping were at all great, it would usually be found that the burners furthest away from the generator give a very poor light.

Nothing of this kind was experienced with acetylene. Being a true gas, atmospheric changes did not affect it, and it could be carried up and down, through flexible tubes, &c., with impunity.

One great drawback of petrol-gas was that unless the plant be a very small one, worked by weight, somebody had to be sent to start the engine, even if only a single light be required, and it often took ten minutes to obtain a light. With acetylene, on the other hand, it was simply a question of up turning a by-pass, as with coal-gas or, where one is more economically minded, of simply turning a tap and applying a match.

And it was just when there were only a few lights required (as was the case practically every day in every house) that petrol gas became so expensive, for the engine had to be kept running all the same. As acetylene required no engine or motor, the use of a single light did not cost more proportionately than the maximum number in the house.

The author had also met with cases of the lighting giving out through stoppage of the engine. Finally, there was one more inconvenience, viz., the obligatory use of mantles.

GENERAL APPEARANCE.

The author said that every one knew the colour of an incandescent burner, and the trouble experienced in giving a pleasant appearance to it, especially when it was desired to use it in connexion with silk and similar shades.

On the other hand, the acetylene light, the nearest to sunlight of all artificial illuminants, lent itself far better to artistic use, and showed persons and objects—and especially colours—in a far more favourable way than incandescent lights.

In the **discussion** that followed this paper several speakers referred to disadvantages of petrol-air gas plants; for instance, it was stated that the apparatus worked much better in summer than in winter.

Mr. Gaster, who was present at the Conference as editor of *The Illuminating Engineer*, regretted that there was not more opportunity of hearing what was to be said on the other side of the question. He also took exception to the assumption that acetylene was the best light from a physiological point of view, based on opinion only. This question demanded careful scientific consideration, and ought to be definitely settled by experiment, instead of being regarded as a matter of conjecture.

M. R. Granjon contributed an interesting and useful table of statistics relating to 10,000 installations in France, in the eight districts of Marseilles, Paris, Bordeaux, Lille, Nancy, Toulouse, Rouen, and Nantes. The table refers to the years 1897 to 1907, and is a wonderful record of the system of inspection undertaken by the Union of Owners of Acetylene Apparatus.

Full particulars are given of the number of instalments visited in each district, the profession of those owning them, the date of installation, the nature of the system and service, the number of burners in use, &c., and also the recorded opinion of the inspector as to whether the installation ought to be classed as excellent, satisfactory, or defective.

M. Louis Cadenel contributed a note on 'The Manufacture of Mantles used for Incandescent Lighting by

Means of Acetylene,' of which the following is a short abstract.

The process of manufacture of mantles destined to be used with incandescent acetylene burners differs in several essential points from that employed in connexion with mantles intended for use with coal-gas, petrol-air, &c., and a series of researches on this subject have recently been carried out by " l'Office Central de l'Acétylène."

In the first case it may be observed that the exceedingly hot flame utilized in the acetylene incandescent burner tends to tear and deform mantles of the ordinary variety, being much higher than that to which they were subjected in the ordinary process of manufacture.

The simple remedy consists in carrying the temperature of such mantles to a much higher point than usual in the process of manufacture, either by utilizing high-pressure gas, or by substituting acetylene for ordinary town gas.

It is now possible to manufacture mantles intended for use with acetylene capable of withstanding the deteriorating action of the acetylene flame, to the same extent as those employed with ordinary gas, provided the acetylene used is chemically pure. It is, however, necessary to make these mantles both smaller and more solid, and in other respects different from ordinary mantles, in order to withstand this high temperature.

One might imagine that it was easy to increase the solidity of a mantle by merely increasing its density. Were this the case, the problem of manufacturing an indestructible mantle would have been solved long ago. Unfortunately any increase in density is accompanied by a corresponding loss in illuminating power: indeed it may be said that the more fragile a mantle the greater its illuminating power. Naturally we have to strike a balance between these conflicting conditions in the case of the ordinary gas mantle.

But the problem in the case of mantles intended for use with acetylene is somewhat different. For, these mantles being so very much smaller than those of the ordinary kind, it is permissible to employ solutions of certain rare and expensive salts, not ordinarily employed without too greatly increasing the cost of manufacture. Thus an acetylene mantle weighs only a quarter of what an ordinary mantle does, and may therefore be made of materials four times as expensive.

The process of impregnation, however, is a very complex one, and it is only after prolonged experiment that we have obtained the desired results. For instance, the best composition and density of the solution employed are dependent both on the size of the mantle and the pressure to which it is subjected.

Practically this last consideration has not been troublesome because we nearly always utilize acetylene under a pressure of 10 to 12 cms. of water. If, however, we consider generators as being broadly divisible into two main classes, producing gas at pressures of 8 and 15 cms. respectively, it becomes necessary to alter the impregnating solution so as to produce the best mantle to meet both conditions.

Another question of interest is the exact form that should be given to mantles intended for acetylene. The best shape proved to be a cylindrical mantle, the diameter of which was about two-thirds of its height, and slightly conical towards the upper end and aperture. This form has the advantage of not distorting the flame, and permits the use of very low pressures. The shape is so contrived that, in the event of the flame smoking, owing to the injector becoming choked or a sudden fall in the pressure, the soot is not allowed to soil the mantle.

The construction of the head of the mantle also demands attention. In the ordinary process of manufacture, the web of the mantle is plaited together and soaked in a solution of " fixcine " in order to give the necessary solidity. This, however, is only attained with a certain loss in illuminating power. This matters but little in the relatively large mantles used in gas lighting, but is more serious in the case of the small acetylene ones.

We have altered the usual system somewhat, in order to secure a homogeneous mantle, and to avoid this loss

in illuminating power, by utilizing very fine strands to effect the junction at the head of the mantle, and also by employing an exceptionally dilute solution, which does not injure the illuminating power.

In conclusion it may be said that the manufacture of mantles of such small dimensions demands special care in every phase of its construction.

Dr. Letang, of Paris, contributed a note on 'An Improved Manchester Burner.' This type of burner, he explained, is characterized by the use of two separate jets, which are projected against one another, with the result that a flame shaped somewhat like a butterfly is obtained.

It would, he thought, be of interest to see if any of the earlier forms of this burner did not utilize a combined supply of gas and air. This system is eminently suitable for promoting the combustion of gases rich in carbon, such as acetylene; it is also useful in preventing the choking up of the orifices by which the gas escapes. The burner invented by Legris half a century ago seemed to fulfill the conditions.

In the construction of acetylene burners it is necessary to confine oneself to the use of refractory materials for portions with which the heated gas comes in contact, because most metals tend to create polymeric forms of acetylene which rapidly obstruct the burner. Steatite is a material that yields excellent results.

The efficiency of such burners depends on the amount of gas consumed. Thus a 10 litre burner will give 1 carcel at 8·2 litres per hour, while the 21 litre burner gives the same result at 7·1 litres. These results are effected by the angle between the two jets; the best conditions are obtained, not by the 90° commonly adopted, but by an inclination of about 65°. The distance between the two orifices may be fixed at 10 mm., the base of the "butterfly" being then 3 mm. above the burner, and no deposit of soot formed.

In conclusion, the author considers that the Legris burner, though invented in 1860, may justly be considered not only the first as regards date, but embodying the essential principle of all modern acetylene burners.

A paper dealing with 'A New Form of "O.C.A." Burner' was also read by **M. Eberhard Held,** of Paris.

This incandescent burner was stated to be exceedingly simple in construction, and devised on lines intended to reduce all danger of obstruction to a minimum, and to facilitate the clearing of the orifice without subsequently interfering with the shape of the jet of gas, as is liable to occur.

One essential characteristic of the burner was the use of a special spiral spring which replaces the gauze usually employed, and serves the double purpose of promoting the mixture of gas and air, and preventing the gas from lighting back. All parts of the burner are easily removed and replaced.

M. Pierre Rosemberg contributed a short note on the value of statistical data on acetylene lighting, and explained how proposals had already been put before various associations that a uniform system of tabulation should be adopted, and that data relating to the number of consumers and lamps in use in different towns, &c., should be compiled and systematized by the International Committee, who would afterwards publish the collected results for the benefit of all participating.

Other papers presented before the Congress included :—

J. W. Gatehouse, Chemist to the British Acetylene Association, 'A Method for the Estimation of Certain Subjects Produced during the Combustion of Acetylene, &c.'

Dr. A. Fraenkel, Vienna, 'The Phenomena of Haze in Acetylene Combustion.'

Maricheau Beaupre, Paris, 'On the Impurities of Acetylene, their Determination and their Elimination.'

Pitaval, Paris, 'Acetylene Lighting in Mines in France.'

Dr. E. Schumacher-Kopp, Lucerne, 'The Illumination by Acetylene of the Locomotives of the Gothard Railway.'

On the Theory of the Globe Photometer.

SEVERAL articles bearing on the practical application of the globe-photometer to practical photometry have already appeared in *The Illuminating Engineer* (see Vol. i. No. 3, p. 230, and No. 4, p. 274). It may, therefore, be of interest to consider in greater detail the theory of an instrument which enables the mean spherical candle-power of any source, whatever be the nature of the distribution of light from it, to be obtained by means of a single measurement. In doing so, we rely mainly upon the recent contributions of Prof. Ulbricht on the subject, and also upon information specially furnished by him for the purpose of this article.

As a starting point to these considerations we may quote the following statement, which occurs in the first of the series of articles mentioned above (*Elektrotech. Zeitschr.*, 1900, p. 595) :—

"Any diffusely reflecting surface, such as that obtained by means of a suitable coating of chalk, &c., when uniformly illuminated by means of an external source, behaves very similarly to a surface which is itself generating and emitting light in a uniformly distributed manner. Could we, instead of close resemblance, obtain *exact* similarity, the following relation would be rigidly true :—

"The unit element of surface, illuminated by means of a flux of light, B, would present the exact surface-brightness

$$H_1 = (1 - a)\frac{B}{\pi}$$

whatever be the direction in which it is viewed ; here a represents the fraction of the light striking the surface which undergoes absorption in consequence.

"In reality, however, diffuse reflection is invariably accompanied by a certain amount of regular reflection, and minute shadows are also formed owing to the small irregularities of the surface. Nevertheless the conditions of pure diffuse reflection can be sufficiently nearly approached for us to be able to lay the basis of a process by means of which the mean spherical intensities even of sources yielding very diverse polar curves of distribution of light, can be obtained. Assuming, however, that the relation

$$H_1 = (1 - a)\frac{B}{\pi}$$

is rigidly true, any surface element, forming part of a hollow sphere of ~~radius~~ diameter 2r, and illuminated by means of the flux of light B, will transmit to each other unit of surface the same flux of light,

$$\frac{(1 - a)B}{4r^2\pi}.$$

This arises from the fact that the effect of surface-elements being unequally inclined to the rays striking them, is neutralized by the relations between their various distances.

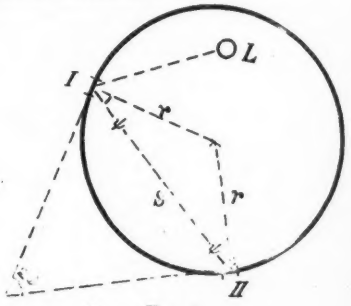


FIG. 1.

"A completely uniform illumination of the interior of the globe thus results. Moreover, since each illuminated surface element taken by itself illuminates all others in a uniform manner, we see that *the illumination due to diffusely reflected light is the same in every portion of the interior of the globe, however unevenly distributed the direct illumination of the interior of the globe may be.*"

The condition of things can be represented by the behaviour of the two surfaces I and II in Fig. 1.

The two surfaces in question form part of the inner surface of a sphere, and reflect light in a rigidly diffused manner according to the cosine law. They are at distances from one another, and inclined at an angle 2ψ. Both

surfaces have unit dimensions. Surface I is illuminated by a source L, receives as a result the flux B, and attains to the surface-brightness H_1. As seen from the surface II it appears to possess a magnitude $\cos\psi$ and an intensity $H_1 \cos\psi$. The rays emitted from it strike the surface II at the angle $\frac{\pi}{2}-\psi$, and thus give rise to the intensity of illumination $\frac{H_1 \cos\psi . \cos\psi}{S^2}$

Hence the illumination of II, obtained from I, becomes $\frac{H_1 \cos^2\psi}{4r^2 \cos^2\psi} = \frac{H_1}{4r^2}$ and is therefore independent of ψ, and the same for all portions of the globe. What is true of the behaviour of a small portion of the illuminated surface of the globe must also naturally hold good for the total illuminated system. Since, however, the light striking any point in this surface is once more

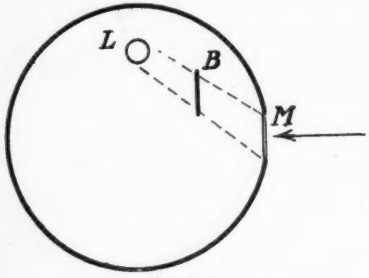


FIG. 2.

reflected with an intensity diminished by absorption, we see that a series of consecutive reflections of ever-weakening intensity will occur, with the ultimate result that the entire inner surface of the globe becomes evenly illuminated.

Let Φ represent the entire flux of light enclosed within the globe, and let a be the absorption-fraction of the inner coating, which is usually about 0·2. A flux of light, reflected to and fro within the globe of the magnitude $\Phi(1-a) + \Phi(1-a)^2 + \Phi(1-a)^3 + \ldots = \Phi\frac{1-a}{a}$, is thus formed. The reflected light falling upon any surface-element in the globe thus becomes $\frac{\Phi(1-a)}{4\pi r^2 a}$.

It is therefore only necessary to creen some point in the surface from all the *direct* light to obtain an intensity of illumination at that point which is a measure of the total flux of light Φ.

This is equally true whether the source of light is placed at the centre of the globe or eccentrically—the result following immediately from the fundamental principles previously explained.

The photometer, therefore, as shown in Fig. 2, consists essentially of a hollow sphere, the inner surface of wh ich is coated with a white diffusely-reflecting material; a small opening M, provided with an opal glass screen, is made in the side of the globe, and is protected from the direct rays of the source of light to be studied, by means of the screen B. The brightness of illumination of this window M can be obtained by the application of a photometrical-bench outside in the usual way. Or the diffusing glass screen may form at once a portion of the inner surface of the globe, and also a portion of a small portable photometer of the Weber type. In any case, the intensity of illumination thus determined is directly proportional to the flux of light Φ, and therefore also a measure of the mean spherical candle-power J_o, of the source to be investigated. Thus if H_M denote the intensity of illumination of the window M, we have :—

$$J_o = \frac{\Phi}{4\pi} = K_o H_M.$$

In order to determine the constant of calibration K_o a comparison lamp, for which Φ_o or J_o has been previously measured by means of its polar curves of distribution of light, is introduced into the globe. When a series of measurements are to be made it is preferable, as Prof. Ulbricht, in his second contribution (*Elektrotech. Zeitschr.*, 1905, p. 512), suggests, to place both the source of light to be studied, L, and the comparison lamp L_1 together with their respective screens B and B_1, simultaneously inside the globe. By extinguishing L and lighting up L_1 instead, the constant of calibration K_o can be determined.

The value of this constant depends upon the coefficient of reflection of the inner coating of the globe, which, of course, is subject to alteration with

age, and also depends, to some extent, upon the foreign bodies within the globe. Prof. Ulbricht has shown that the influence of these "foreign bodies" such as screens, parts of lamps, &c., can be reduced to negligible dimensions. He has, however, determined the magnitude of the error that can be caused by the absorption and obstruction of light on the part of the screens used in this work, and found that it is a minimum when the distance of the screen from the lamp is about 0·4 times the distance of the latter from the measuring aperture.

Prof. Ulbricht has also developed a method for the measurement of mean hemispherical candle-power, in which the diffused reflection of only a portion of a spere is utilized. In this case also a uniform illumination of the surface exposed is obtainable; it is only necessary to guard against the possibility of light entering by the opening so produced.

The use of the globe for this purpose is shown in Fig. 4. It will be seen that the cap of the sphere has been removed, the source of light being placed in the plane of section. Under these conditions the globe only receives the light in the lower hemisphere, and its internal illumination therefore serves to measure the mean hemispherical candle-power, in precisely the same manner as was previously described. The determination of the constant of calibration is accomplished by the use of a comparison lamp, which is screened by the use of a small cap in such a way that no light from it crosses the plane of section of the globe. The mean spherical candle-power of this lamp can be determined by previous comparison with an unscreened standard lamp. We thus determine the mean hemispherical flux of light $\Phi_{\supset}$, which is connected with the mean hemispherical candle-power $J_{\supset}$ by means of the relation, $J_{\supset} = \frac{\Phi_{\supset}}{2\pi}$. Instead of actually removing a portion of the globe altogether we can replace it by a similar portion, the inner surface of which is of a dead black non-reflecting character.

In order to measure the mean hemispherical candle-power of sources of light which cannot be considered "point-sources," we must know the exact position in which they should be placed as regards the plane of section—in other words, we must determine their centres of radiation. This question forms the subject of

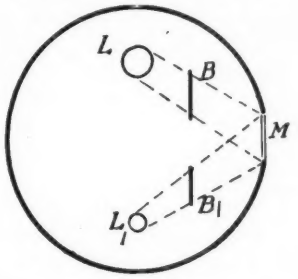


FIG. 3.

Prof. Ulbricht's third contribution (*Elektrotech. Zeitschr.*, 1906, p. 50). He explains that if a source of light is placed at a certain specified distance from a thin horizontal plane plate, for instance, an ordinary paper grease-spot disc, and if this source be raised and lowered until the upper and lower surfaces of such a plate appear equally brightly illuminated, then the centre

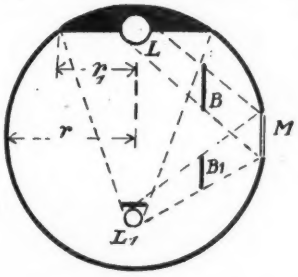


FIG. 4.

of radiation must lie in the plane of the paper in question. If we denote the radius of the circle produced by the cutting of the sphere for the purpose of hemispherical measurement, by r_1, the correct distance of the grease-spot paper from the source of light must be $r_1\sqrt{3}$.

In a fourth contribution (*Elektrotech. Zeitschr.*, 1907, p. 777), Prof. Ulbricht

deals with the influence of screens and its elimination. He also considers the photometry of lamps in clear glass globes, and describes a form of apparatus, in which an arrangement of mirrors enables the observer to inspect the upper and lower surface of the grease-spot disc simultaneously. We are able to show the most recent modification of this apparatus in Fig. 5.

The grease-spot disc F is placed within a blackened tube, at the further end O, of which is situated the eye of the observer. By means of the mirrors SS the observer is able to see both the upper and the lower sides of disc simultaneously. The corresponding images are brought into juxtaposition by means of the two prisms PP, when the lamp, placed at a distance $r_1\sqrt{3}$ from the tube is so adjusted as to cause the appearance of the upper and lower surfaces to be the same, the eye is applied to either the upper or lower aperture O_1. By looking through the opening between the mirrors the observer is now able to determine which point in the light-giving surface coincides with the extension of the plane of the grease-spot disc, which is visible in section as a thin line. This point must be situated in the plane of section of the globe.

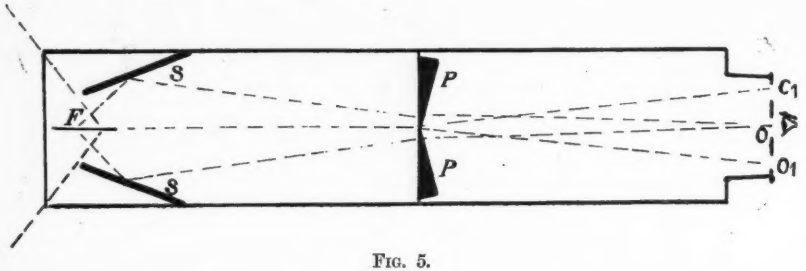


FIG. 5.

From theoretical considerations Prof. Ulbricht derives the following rules, which must be applied to the apparatus shown in Figs. 3 and 4. The surface F of the screens B must not be larger than $\frac{1}{20}$ of the sectional area of the globe. The screen B, as observed through the measuring aperture in the globe, must completely cover :—

(*a*) The actual source itself and its reflectors, in the case of naked lamps.

(*b*) The whole globe, in the case of lamps equipped with a diffusing globe.

(*c*) The source itself, the reflector, and any reflected images of the source of light,* in the case of lamps equipped with clear glass globes.

In any case the dimensions of the screens B, B_1 must suffice to prevent the possibility of even the outer edges of the window of observation being exposed to the direct rays from the source. The extent of the error caused by the screens B and B_1, having surfaces F and F_1 respectively may be computed to be about

$$\frac{80F - 100F_1}{\pi r^2}\ \%$$

in the case of measurements of spherical intensity, and about

$$\frac{50F - 100F_1}{\pi r^2}\ \%$$

in the case of measurements of hemispherical intensity. In what has just been said the radius of the circle formed by the plane of section has been assumed to be about 0·4r. In any case it should not be smaller than the diameter of the luminous source, and not greater than $\frac{r}{2}$. In the case of measurements of spherical intensity L and L_1, as seen from the measuring aperture, should subtend an angle of ± 30 degrees. In the case of measurements of hemispherical intensity the lamp must be so situated with respect to the globe that its centre of radiation lies in the plane of section.

Practical forms of the globe photometer, of which three (shown on pp. 230,

* Such images, formed by reflection in spherical or elliptical glass globes, are a marked feature of most arc lamps.

278, and 280 respectively), have been recently depicted in *The Illuminating Engineer*, range from 0·5 to 3 metres in diameter. The larger instruments, upwards of 1·5 metres in diameter, give the best results. A globe of this description, built in the works of H. Stieberitz of Dresden, is shown in Fig. 6. The larger sizes of globes possess the advantage that the errors of measurement are greatly reduced; they become, indeed, so small as to be negligible in comparison with the ordinary errors of photometrical observation.

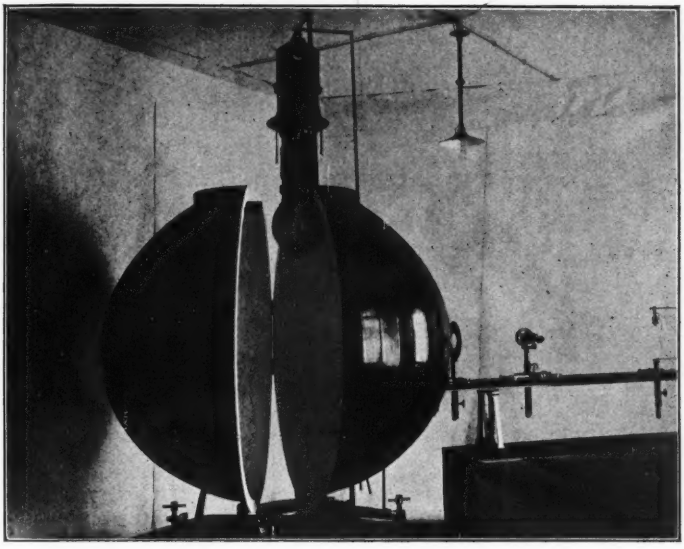
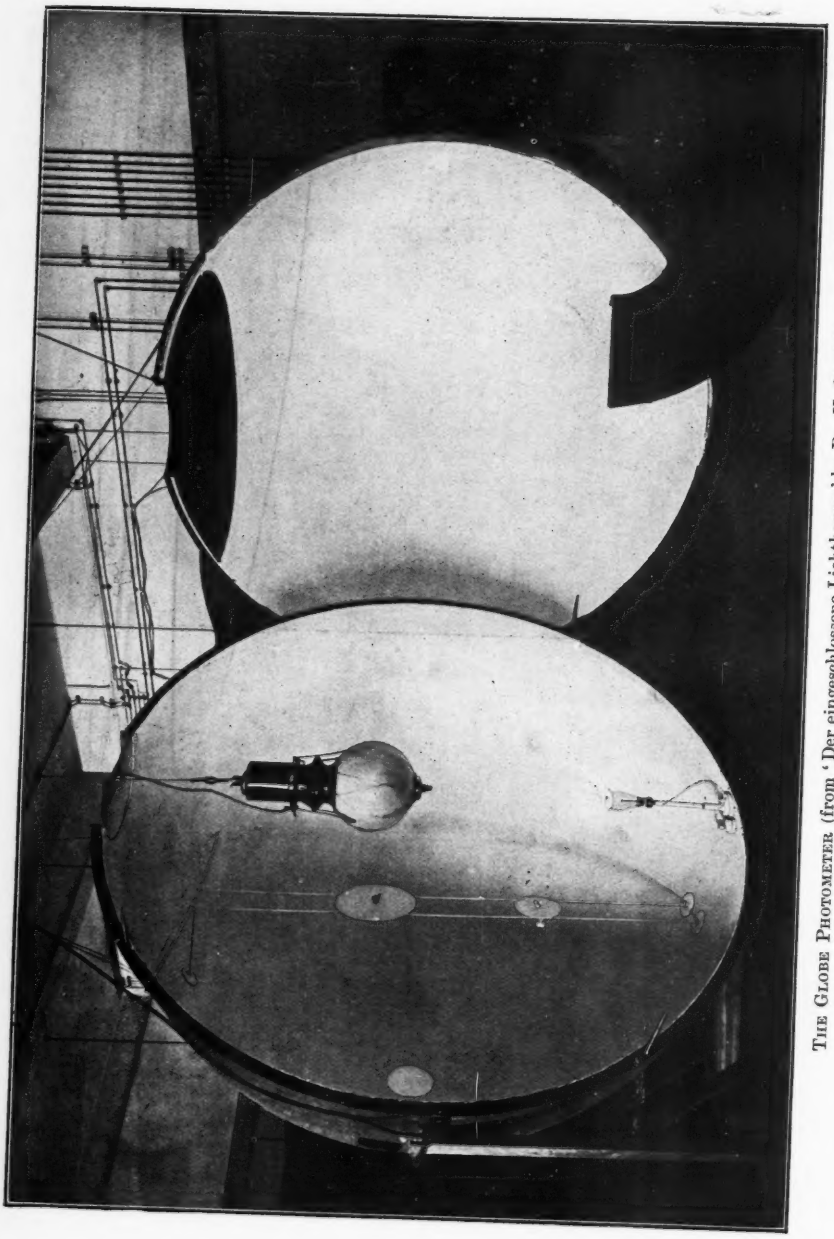


FIG. 6.

On the next page will be found an interesting illustration of a Globe Photometer, which occurs in Dr. Stockhausen's book on the enclosed arc, and to which the author has kindly drawn our attention. This globe was designed for use at the Dresden Technische Hochschule. It is built out of 1 mm. thick pieces of sheet-iron, and is divisible into two halves in order to facilitate access to the interior of the globe.

The illustration shows very clearly the arrangement of the arc lamp to be tested, the various screens and the window, and the position of the comparison lamp within the globe.

This globe, designed by Dr. Stockhausen for the purpose of his experiments, is, we understand, the design on which that of Messrs. Körting & Matthiesen, shown on p. 230 of the March number of *The Illuminating Engineer*, was constructed.



THE GLOBE PHOTOMETER (from 'Der eingeschlossene Lichtbogen,' by Dr. K. Stockhausen, p. 155).

A Simple Method of Determining the Mean Spherical Intensity of a Source of Light.

By E. W. Weinbeer.

Hitherto the graphical determination of the mean spherical intensity of sources from the polar curve of distribution of light has been invariably carried out by means of the Rousseau construction. This method, however, involves the use of a planimeter in order to ascertain the area of the diagram in question.

Kenelly (*Elec. World*, No. 13, 1908) has recently described a new method involving purely linear measurements, by the aid of which the mean spherical candle-power can be determined by the use of a rule and a pair of compasses only. This method is based upon the fact that a given source of light yielding a mean spherical candle-power I, over the region embraced between the two angles ϕ_1 and ϕ_2, measured with respect to a vertical base line, emits a flux of light $2\pi I$ (cos. ϕ_1 – cos. ϕ_2) within these limits. Kenelly's method thus gives us the total flux of light over any desired region—in the lower hemisphere, for instance — expressed as the sum of the individual fluxes of light of which this quantity is made up, and this is obtained by purely linear measurements. The flux of light over the lower hemisphere being $2\pi I \sigma$, this linear measurement will also give us the mean hemispherical candle-power to the same scale as the polar curve of light-distribution.

The formula $2\pi I$ (cos. ϕ_1 – cos. ϕ_2) forms the basis of design of a piece of apparatus, for which a patent has recently been demanded, and which enables the mean hemispherical candle-power of a source to be determined directly from the polar curve without any calculation. This apparatus is shown in the figure accompanying this article, and its action may be briefly described as follows :—

Suppose that the individual fluxes of the source of light to be investigated have been photometrically determined for the angles 85°, 75°, 65°, &c., to the vertical. Now the contribution of these fluxes to the total flux over the hemisphere are $2\pi I_{85}$ (cos. 80° – cos. 90°), $2\pi I_{75}$ (cos. 70° – cos. 80°), &c., in accordance with the formula referred to above. The actual values of the trigonometrical expressions occurring in this series are as follows :—

cos.	80°	– cos. 90°	= 0·1736
,,	70°	– ,, 80°	= 0·1684
,,	60°	– ,, 70°	= 0·1580
,,	50°	– ,, 60°	= 0·1428
,,	40°	– ,, 50°	= 0·1232
,,	30°	– ,, 40°	= 0·1000
,,	20°	– ,, 30°	= 0·0737
,,	10°	– ,, 20°	= 0·0451
,,	0°	– ,, 10°	= 0·0152

the sum of which is equal to unity.

These figures enable the individual fluxes of light—or, leaving out of account the constant quantity 2π—the values of the individual intensities corresponding to the various angles, to be determined. The author has utilized this principle in the device shown in the figure, which resembles an ordinary slide-rule. The upper edge of this is provided with a convenient scale ranging from 0 to 10 or 0 to 100, &c.

The lowest scale in the figure is exactly similar, except that it is reduced in the ratio 0·1736 to 1. It will be seen that there are in all 9 successive movable rules, the first of which needs no scale at all, and the second receives the same scale as the upper one, but reduced in the ratio 0·0152 :1, while the remaining scales are similarly reduced in the ratios 0·0451, :1, 0·0737 :1, &c.

In order to obtain the results following the application of the above formula we proceed as follows: the zero of the lowest movable rule (marked on the figure 85) is adjusted so as to be opposite to the value of I_{85} on the scale below it. Next the second movable rule from the bottom (marked 75 in the figure) is adjusted in exactly the same way, so that its zero is opposite the value of I_{75} as read on the rule 85, and so on, until eventually we can read the summation of all the terms in the series by the reading of the end of the movable rule 5 on the top fixed edge.

The apparatus may be provided with a greater or smaller number of movable rules at will; naturally the accuracy increases with the number adopted. The fundamental fixed scale on the fixed upper edge may also be constructed to any desired value of luminous intensity—to 32 candle-power lamps, for example—or an ordinary slide-rule may be added to the apparatus, thus enabling the final results to be reduced in any desired ratio.

In any case the essential features of the device are the same, namely, a number of movable scales graduated according to the system outlined above. A very cheap and simple modification of the arrangement may be obtained by merely printing the various scales required upon a single fixed rule. In this case it would be necessary to prick off the various lengths on a straight line with a pair of dividers, and then to measure the resulting length by the fundamental non-reduced scale at the top of the figure. The length so obtained gives the mean hemispherical candle-power.

In order to obtain mean spherical candle-powers all that is necessary is to repeat the process for both hemispheres, and to take the arithmetic mean.

Recent Developments in Electric Lighting.

THIS formed the title of a series of three lectures delivered by Prof. J. T. Morris, M.I.E.E., on June 15th, 22nd, and 29th, at the East London Technical College. The lectures were extremely well attended, and the evident appreciation of those present was both a tribute to Prof. Morris and an illustration of the interest which is invariably aroused by a series of lectures dealing with progress in lighting and illumination.

In his first lecture, at which Sir Wm. White, K.C.B., F.R.S., presided, Prof. Morris dealt mainly with the arc light and recent developments in arc lamps, his remarks being illustrated by exhibition of many of the most recent types, including the Excello, the Oriflamme, the Jandus Enclosed, &c., and also exhibited one of the latest Keith gas lamps. On the following Monday this branch of the subject was again dealt with, special attention being paid to the use of flame and impregnated carbons, and the influence of the nature of these carbons on the colour of the light. Subsequently the lecturer dealt briefly with street illumination and photometry, and referred to the report of Mr. A. A. Voysey on the City lighting.

We write this before the third lecture of the series has been delivered, but we understand that this will deal with glow lamps, and include a comparison of the costs of gas and electric lighting.

Report on the Public Lighting of the City of London.

By A. A. Voysey,

Electrical Engineer to the Streets Committee of the Corporation of London.

PUBLIC HEALTH DEPARTMENT.

To the Worshipful the Streets Committee.

Gentlemen,—It is now my duty to report on the subject of the Public Lighting of the City, having regard to recent experiments which have been made with a view to improve and cheapen it.

In the first place, I propose briefly to refer to what is called the science of photometry, of which I have made some use for the purpose of this investigation.

Many people even to-day, in dealing with questions of artificial light, are content with a statement of the candle-power of the source of light—a statement frequently as false as it is vague—taking no account of the directions in which light is given, of the globe, lantern, reflector, position and surroundings of the lamp, all factors of the utmost importance in determining the useful lighting effect. However important the study of the source of light may be, the study of the actual illumination in the street under working conditions is far more essential. In 1892, the work of Mr. A. P. Trotter, now the Electrical Adviser to the Board of Trade, showed the lines on which such an examination might proceed, and at the same time provided an excellent illumination photometer for the purpose. I worked a great deal with this instrument in the City in 1896, taking measurements of the illumination on a horizontal surface six inches from the ground and formed the opinion that the illumination measured on a horizontal surface may be taken as a sufficient indication of the effective lighting of a street. I am now again led to the same conclusion. But as the tendency is to measure illumination at a height of 4 ft. from the ground, my recent tests have been made at this level. The photometer used is an improvement on the one used in 1896, and was sent to the National Physical Laboratory for verification.

The unit of illumination is that produced by 1 candle-power at a distance of 1 ft. and is called 1 candle-foot.

Attached hereto will be found some curves showing the illumination given in Holborn, Cannon Street, and Queen Street by the experimental lamps. The length of the street in feet is plotted along a horizontal scale and the vertical scale is marked in candle-feet and fractions thereof, so that the curves show the variation in illumination along the street.

Curves A show the illumination along the curb line given by flame-arc-lamps in Holborn Viaduct and Cannon Street and by gas in Queen Street.

Curves B are similar, but are taken along the centre of the road.

Curves C show the difference in illumination along the curb in Cannon Street, between the central suspension of lamps at a height of 28 ft. and lamps on posts at a height of 20½ ft.

Curves D are similar, but along the centre of the road. There is also shown the effect of turning out one of the centrally-hung arc-lamps.

Curves E show the effect of suspending the lamps in Cannon Street at 26 ft. instead of 28 ft.

Curves F show the effect of lighting Tower Royal with the centrally-suspended flame arc-lamp in Cannon Street, with a flame arc on a post and with two incandescent gas lamps.

The arc-light curves marked A and B are each taken as the mean of several curves, and the atmospheric conditions, when the tests were made, were clear and favourable.

The curves C, D, E, and F were taken with a view to make specific comparisons, and they each represent a single set of observations. The atmospheric conditions prevailing when

Next, I have formed the opinion from observation and testing that the minimum illumination is the most important factor in good lighting, and I have come to the conclusion that about one-tenth of 1 candle-foot is the minimum below which it is not desirable to go in the main streets of the City. If that figure is adopted and maintained, then I think that the

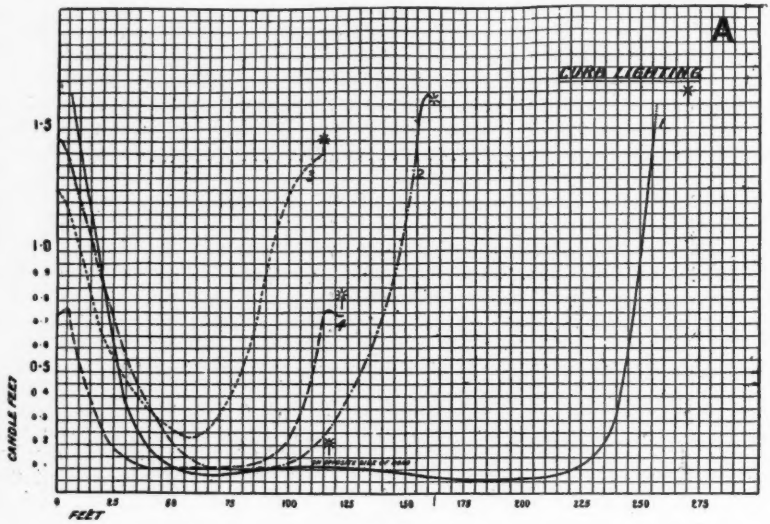


TABLE A.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination.			Width of Street.	Relative Cost.
					Max.	Avg.	Min.		
				ft. in.				ft. in.	
1	Holborn Viaduct	Flame Arc	10·6	20 5 post	2·0	0·41	0·05	77 5	118
2	Cannon Street	Do.	11 0	28 0 central	1·6	0·56	0·1	50 0	100
3	Do.	Do.	11·0	Do.	1·4	0·12	0·23	50 0	139
4	Queen Street	High pressure gas two mantle	...	13 0	0·76	0·29	0·1	50 0	196

curves E were taken were distinctly inclined to be foggy.

It is now necessary to consider what conclusions can be drawn from the curves. I have already stated that I think the illumination given on a horizontal surface can be taken as a sufficient indication of the value of the lighting in a street.

main streets of the City will be very well lighted. If the curves for Holborn Viaduct are studied, it will be seen that, although Holborn Viaduct is a very wide thoroughfare, the lighting is not very far from complying with the minimum value, which I think necessary.

In order to meet any possible objection to unpleasant colour, the Holborn

Viaduct lamps are trimmed with carbons giving a pleasantly-toned light, but the illumination is thereby reduced. If 7 m/m and 6·35 m/m (cores $\frac{3}{32}$ in. and $\frac{1}{16}$ in. respectively) carbons are used in Holborn Viaduct, giving a yellower light, the minimum illumination would be increased so as not to fall far short of the necessary value, and it could be regarded as approximately fulfilling what I think are the reasonable requirements for the sufficient lighting of a City main street. I do not think that Holborn Viaduct can properly be compared with Cannon Street, because, in addition to other reasons, the width of the Viaduct is about 50 per cent. greater than the width of Cannon Street.

Therefore I determined to make another test in Cannon Street, first with the centrally-hung lamps as used at present, and then with identical lamps on posts on the footway, keeping the conditions of current and carbons the same for both. The arrangements for this test were kindly made for me by the City of London Electric Lighting Co., and the results shown in curves

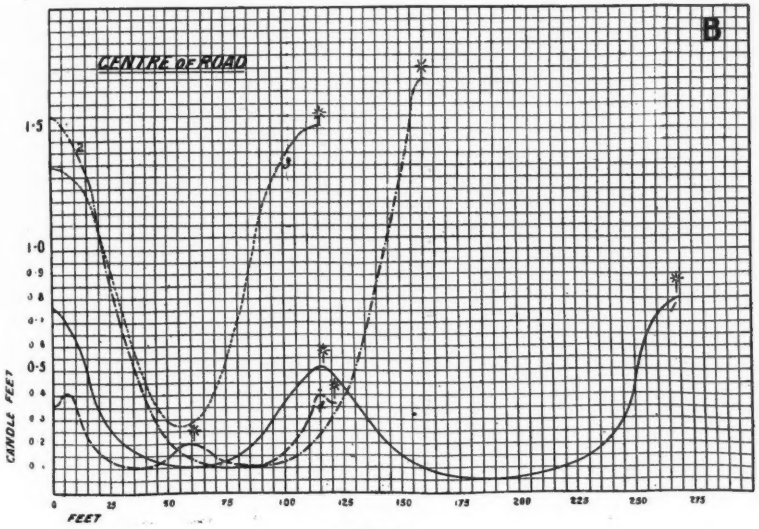


TABLE B.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination. Max.	Avg.	Min.	Width of Street.	Relative Cost.
				ft. in.				ft. in.	
1	Holborn Viaduct	Flame Arc	10·6	20 5 post	0·8	0·28	0·06	77 5	118
2	Cannon Street	Do.	11·0	28 0 central	1·7	0·66	0·10	50 0	100
3	Do.	Do.	11·0	Do.	1·5	0·88	0·28	50 0	139
4	Queen Street	High pressure gas two mantle	...	15 0 post	0·4	0·21	0·10	50 0	196

C and D indicate the advantage obtained by central hanging in a street such as Cannon Street, which is fairly typical.

The illumination curves of the centrally-hung lamps in Cannon Street show that the lighting also fulfils the suggested condition that the minimum should not be less than one-tenth of

1 candle-foot, and I think the curves are very good ones, and indicate what is obvious from an examination of the street, namely, that the lighting is very good and, if we study the curves, the advantages of the central suspension and the extra height of the lamps are evident. From the central suspension there is, however, an additional gain for side streets and at the junctions of streets, owing to the fact that the light of one lamp can be used over a greater area. For instance, 45 per cent. of the cost of lighting in Cannon Street is saved on gas in the side streets. This economy could, to some extent, be obtained by placing posts at the corners of streets, but I do not think it could be obtained to the same extent as is possible with the higher centrally-hung lamp.

An experiments was made in Cannon Street at the suggestion of the late Chairman, Mr. Stopher, some of the lamps being hung at 26 ft. instead of 28 ft. The result is given in curves E, which, I think, show that the higher position is slightly better than the lower one.

Curves F show the illumination in Tower Royal, a turning off Cannon Street, lighted by the centrally-hung arc-lamp, and by the arc-lamp on a standard in Cannon Street, and by the two incandescent gas lamps on brackets in Tower Royal. The curves show the advantage of the central suspension.

Attention should be drawn to curve D, No. 3, which shows the effect of extinguishing alternate lamps in Cannon Street. The curve does not fulfil

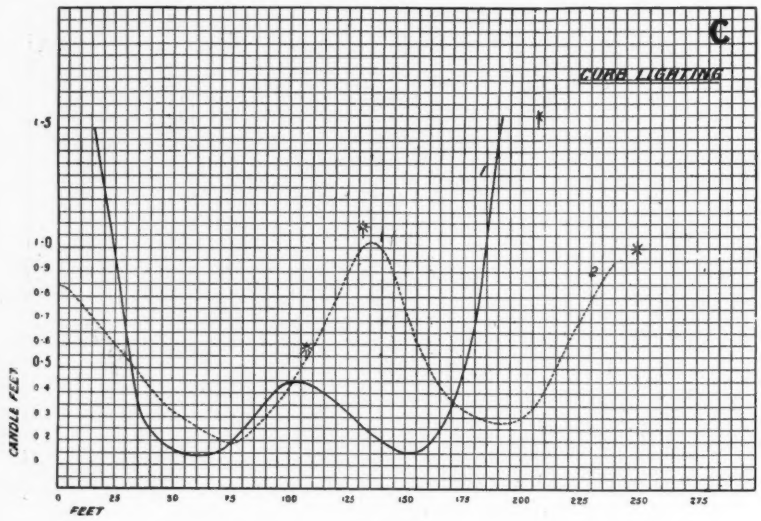


TABLE C.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination. Max.	Avg.	Min.	Width of Street.	Relative Cost.
				ft. in.				ft.	
1	Cannon Street	Flame Arc	11·0	20 5 post	2·0	0·68	0·14	50	155
2	Do.	Do.	11·0	28 0 central	1·02	0·56	0·19	50	127

the requirements of a well-lighted main street, but it shows a better result than Queen Victoria Street, and the lighting is very fair. If it were not for the fact that the cleansing of the streets is an operation which may be greatly assisted by good lighting, I should be inclined to recommend the turning out of half the lights in main streets at midnight, and I think the reasonable reduction were made in the annual charges. It is now desirable to consider the question of comparative cost, and this is bound up with the question of spacing.

The average distance between the centrally-hung lamps in Cannon Street is approximately the same as that of the standards in Holborn, though Holborn is 50 per cent. wider than

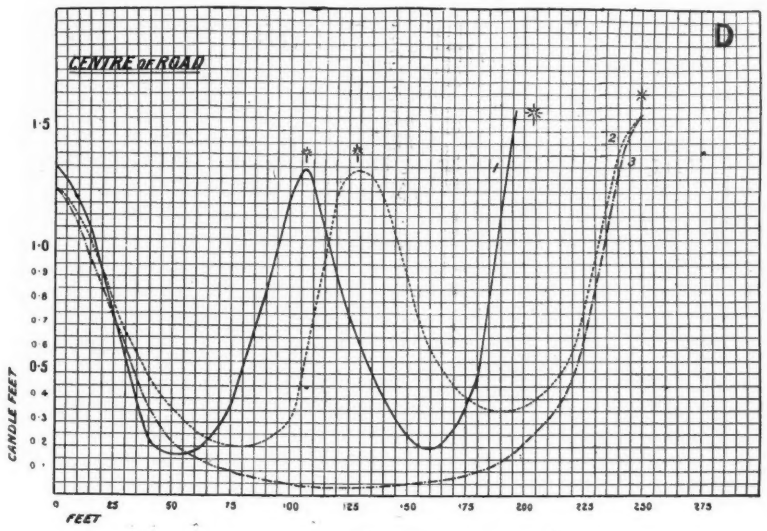


TABLE D.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination.			Width of Street.	Relative cost.
					Max.	Avg.	Min.		
				ft. in.				ft.	
1	Cannon Street	Flame Arc	11·0	20 5 post	2·0	0·7	0·17	50	155
2	Do.	Do.	11·0	28 0 central	1·56	0·72	0·2	50	127
3	Do.	Do.	11·0	28 0 central	1·56	0·4	0·04	50	64

matter is worth consideration. This is, perhaps, an opportune place to discuss the question of lighting hours. In my opinion the fixing of lighting hours between sunset and sunrise is a mistake, and I think the lighting might be curtailed on an average of about one hour per day, half in the morning and half in the evening, if a Cannon Street. The average spacing of the centrally hung lamps in Cannon Street is a little closer than the spacing of the old standards in that street, there being eleven of the suspended to ten of the lamps on standards. The extra lamp results really from the consideration of the side streets rather than from any need in Cannon Street

itself. With regard to spacing, a regular distance should be followed as closely as possible, but due consideration must be paid to side streets and cross streets in order to obtain the most economical results. As will be seen from the curves, the distance between the lamps in Cannon Street varies from 112 ft. to 165 ft. I think the latter distance may be regarded as the extreme, beyond which it is not desirable to go; whereas the former is closer than is necessary, and can only be justified by a consideration of the side streets.

For the purpose of comparing the effect of gas with electric lighting I made a test in Queen Victoria Street, but I found a large portion of this street with a very low illumination, and neither from observation nor test did it appear to me at all comparable with Cannon Street. I therefore sought out a piece of good gas lighting, and I found this in a portion of Queen Street. It was interesting to find that the piece of street I picked fulfilled the condition which I had fixed as essential for a well-lighted street, namely, that the illumination on a horizontal surface 4 ft. from the ground should in no place be less than one-tenth of 1 candle-foot. The average illumination of the picked piece of gas-lighting in Queen Street, which is, fortunately, just the same width as Cannon Street, is only about half that in Cannon Street, though it is about

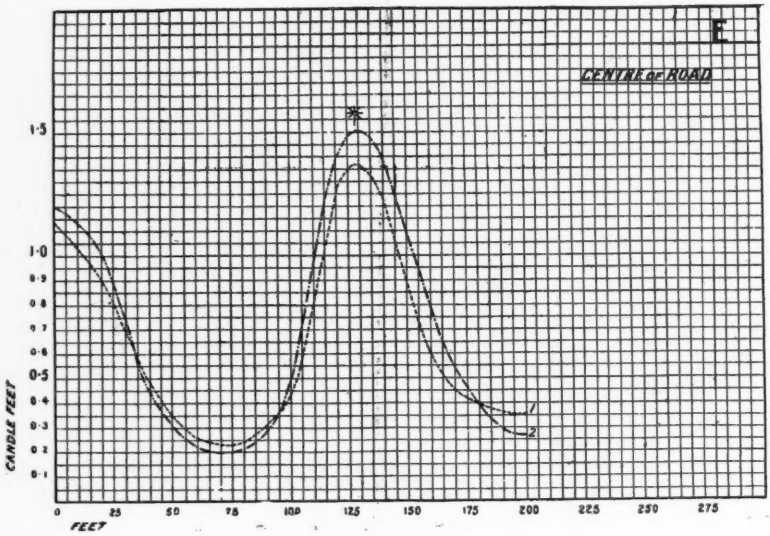


TABLE E.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination.			Width of Street.	Relative Cost.
					Max.	Avg.	Min.		
				ft.				ft.	
1	Cannon Street	Flame Arc	11·0	28 central	1·37	0·66	0·23	50	—
2	Do.	Do.	11·0	26 central	1·5	0·72	0·2	50	—

double the cost. This confirms what I reported three years ago as the result of some photometric tests, namely, that, light for light, high pressure incandescent gas-light costs four times as much as the flame arc-light. It may here be observed that Departments of the Corporation, other than the Public Health Department, are now saving at the rate of about 3,000*l.* a year, partly by changing from gas to electricity and partly by bringing electric lighting up to date, and I have good reason for saying that this sum could be considerably added to.

On the whole I think it may be fairly assumed that about 500 eleven-ampere flame arc-lamps will light the main

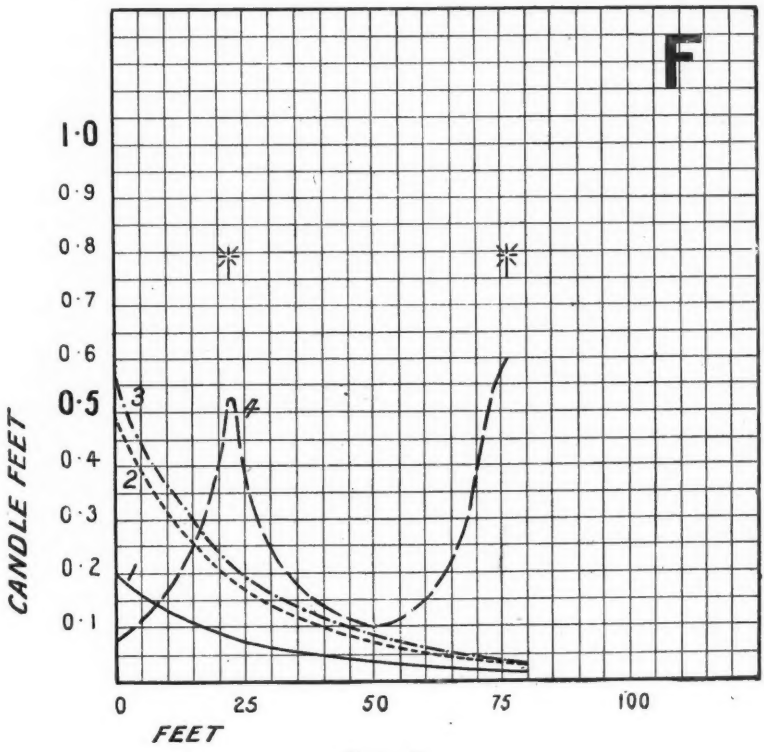


TABLE F.

Curve No.	Street.	Lamps.	Current Amperes.	Height and Support.	Illumination. Max.	Avg.	Min.	Width of Street.	Relative Cost.
1	Tower Royal	Flame Arc	11·0	ft. in. 20 5 on post	0·2	0·08	0·025	...	Nil
2	Do.	Do.	11·0	28 0 central	0·48	0·16	0·04	...	Nil
3	Do.	Do.	11·0	26 0 central	0·56	0·19	0·04	...	Nil
4	Do.	Low pressure gas single mantle	...	11 6 bracket	0·6	0·25	0·08	...	£6 14 4 per annum

streets well, whether centrally hung or on standards. The cost of these at 17*l.* 10*s.* each would be 8,750*l.* The present cost of lighting the whole City is about 22,000*l.* a year, about half the cost being for electric light and the other half for gas. In addition to this a sum of about 17,000*l.* appears to have been spent in the last nine years on providing and maintaining apparatus for gas-lighting. The side streets can be very much better lighted by centrally-hung arc-lamps than they are at present for a sum which I estimate approximately at 5,000*l.* to 6,000*l.* per annum. It is very important in my opinion that the main-street lighting should not be arranged independently of the side streets. Economical effective lighting of both is bound up one with the other. A few lamps arranged in the side streets off Cannon Street would quickly show what can be done. I have very little doubt that the average illumination throughout the whole of the City streets can be at least doubled, and a saving of about 6,000*l.* a year effected.

On the subject of lamp supports, I think it may be remarked, with regard to the central suspension, that the plan followed in Cannon Street of making them as invisible as possible is a good one. Attachments would have to be securely made and the supporting wires carefully examined, and, no doubt, the existence of a large number of such supports in the City would necessitate some extra cost to the Coration in the supervision of overhead wires. But if reasonable care is used in the matter, there should be no danger whatever attaching to the central suspension of lamps.

In the main streets the plan of trimming the lamps in position during the early hours of the morning is a sound one. No doubt some small occupation of the roadway space during busy hours would take place when a lamp went wrong at such a time; but it must be remembered that a standard on the footway remains for several thousands of hours each year as an obstruction to traffic, and must necessarily be a much greater cause of inconvenience than the very occasional visit for a few moments necessitated by a fault in a centrally-hung lamp.

In narrow streets it would be advisable to arrange for bringing the lamps down to the footways for trimming, because otherwise a serious obstruction to traffic would occur. In some very wide streets, like Holborn and Farringdon Street, it might be advisable to use standards placed in the centre of the road, and in any case a certain number of standards may be required.

While I recognize the importance of economy and the consequent need to use existing material as much as possible, I think I ought to point out the unsatisfactory condition of London in the matter of lamp standards, and especially electric lamp standards. The design is usually left to an iron-founder's draughtsman. Mr. Norman Shaw has very kindly given his gratuitous aid in matters affecting the appearance of London, and I think his help might very well be asked. If new posts are found to be necessary, I think some endeavour should be made to redeem the reputation of London in this matter.

I will re-state my main conclusions:

1. That the illumination on a horizontal surface 4 ft. from the ground is a sufficient indication of the useful light in a street.

2. That the minimum value of such illumination is the most important factor in good lighting.

3. That such minimum should not be less than one-tenth of 1 candle-foot.

4. That this illumination can be approximately obtained by eleven-ampère flame arc-lamps with yellow flame carbons, spaced approximately as at present, either on standards at 20½ ft, as in Holborn Viaduct, or centrally hung, as in Cannon Street, at 28 ft. from the ground.

5. That a more even distribution of light and a more economical result can be secured by the centrally-suspended lamp at 28 ft. than by the lamp at 20½ ft. on a standard.

6. That economy and efficiency require the treatemnt of main streets and side streets together.

7. That a demonstration should be made in the side streets of centrally-hung arc-lamps as soon as possible.

8. That about 6,000*l.* a year may be saved and a doubling of the average illumination throughout the City streets effected by flame arc lighting assisted by a few metallic filament lamps where arc-lamps have not a sufficient area for economical lighting.

9. That where central suspension is used, it should be without lowering gear in broad streets and with lowering gear in narrow streets.

10. That any new standards which may be required should be designed according to the advice of some reliable guide, such as Mr. Norman Shaw.

11. That the lighting hours can be reconsidered with a view to economy, without prejudice to lighting efficiency.

12. That the question of reducing the lighting in the main streets at midnight should be considered.

In order to obtain as soon as possible the great advantages in economy and better lighting that I showed to be possible, I think a small demonstration should be invited from both Companies in the side streets, and some of the streets adjoining Cannon Street would be very suitable for the purpose. I also think it would be a great advantage if a provisional decision were come to as to whether the lighting is to be divided between the two Companies, and if so, in what proportions. If that is done, and the side-street demonstration of lighting found satisfactory, then the way will be clear for the preparation of complete plans and specifications for lighting the whole of the City, and instructions might be given accordingly.

I ought to acknowledge the assistance kindly given me by the police, by Mr. Engineer in the lighting and extinguishing of gas-lamps for testing purposes and in supplying me with details of gas costs; also the assistance given by those in my office, which entailed night work. Both the Electric Supply Companies afforded me every facility to measure the current given to the lamps during test, and at their own expense made the temporary arrangements which were required in Cannon Street for testing purposes.

I have the honour to remain,
Gentlemen,
Your obedient Servant,
A. A. VOYSEY.
Electrical Engineer.

The Annual Meeting of the Institution of Gas Engineers.

THE annual meeting of the Institution of Gas Engineers took place from June 16th to June 18th. From the standpoint of the gas engineer the meeting seems to have been a complete success, and the papers, though none of them dealt with the lighting side of gas technics, reached a high order of merit.

The address of the President, Mr. Doig Gibb, M.I.C.E., covered a wide range of subjects, but contained several references to matters of interest to the illuminating engineer. We appreciate Mr. Doig Gibb's comments upon the value of competition between gas and electricity in having educated the public to demand a more liberal standard of illumination, and especially his testimony that he regards misleading statements on the part of his rivals as less frequent. We feel that any one who had been impartially following the progress in both sections of lighting would admit that there has been misrepresentation on both sides, and we are glad to believe that the folly of such misunderstandings is becoming realized by those in both camps.

As the President said, companies relying on such tactics can hope to gain no real success by them. It is pleasant, too, to have his recognition that all systems of lighting have their own sphere of activity. "There is a field for electrical supply companies, and I have no doubt that they will increase and prosper, as gas under-

takings have done, and will do." In this connexion it is interesting to note that in Newcastle recourse was had to electrical driven fans supplied by two 30-kilowatt dynamos, in order to maintain the pressure at the requisite high level. In his address the President also referred to the spread of methods of automatic street lighting by "pressure waves," and stated that about 500 such installations were now in use in Newcastle with satisfactory results.

An extremely interesting paper was read by Sir George Livesay on 'Co-partnership.' In co-partnership Sir George Livesay saw the only sure and certain settlement of the relations between capital and labour. He testified to its value in promoting a spirit of co-operation between employer and employee, as a result of nineteen years' practical experience. Many, the President remarked, might urge that the present conditions worked well enough, and ask why we could not "leave well alone." But did any man believe that the present conditions of labour and capital could be regarded as entirely satisfactory or could be expected to endure indefinitely?

What was really necessary, however, was not profit-sharing—the mere payment of an annual bonus in cash—but actual shareholding, involving partnership in responsibility.

During the discussion that followed the general aims of the paper, and the spirit between workers and employers for which Sir George was working were generally approved, though there was some criticism of points of detail. Some seemed to fear that in future years the success of the movement might be jeopardized when, eventually, Sir George Livesay's support would no longer be available.

An amusing story was told by Mr. Berridge of a town councillor who had proposed that gas should be replaced by electricity for the public lighting. As a result he was approached by several of the workmen at the local gas works, who explained that if the scheme was not abandoned they would buy no more tobacco at his shop. The matter was dropped.

Among the other papers read before the Institution may be mentioned that by Prof. W. A. Bone, whose recent appointment to the Chair of Fuel at the University of Leeds is an illustration of the attention that is now being devoted to the scientific aspects of gas engineering. Prof. Bone's lecture was entitled 'The Combustion and Thermal Decomposition of Hydrocarbons.' Among other points the lecturer dealt with the theories which have been put forward to explain the chemical basis of the luminosity of flames, and the effect of temperature upon the decomposition of the hydro-carbons participating in these reactions.

Another valuable paper, which also illustrated the scientific spirit in which problems connected with gas engineering are now attacked, was that by Mr. Bywater dealing with refractory materials.

On Thursday, June 18th, the meeting took place at the Franco-British Exhibition, where the various gas exhibits received attention.

The meeting of the German Institution of Gas and Water Engineers took place from June 15th to the 19th, which was attended by many English gas engineers, and at which representatives from all the chief European countries were present. Amongst the items on the programme of the meeting may be mentioned a visit to the works of Messrs. Ehrich & Graetz, and an address by Prof. Drehschmidt on the public lighting of Berlin.

The following papers were also read:—

'Continuous Carbonization in Vertical Retorts,' by H. W. Woodall, of Bournemouth; 'Recent Experience with the Dessau Vertical Retorts,' by A. F. P. Hayman, of Berlin; 'Description of the New Gasworks at Valby, Copenhagen,' by J. Irminger, of Copenhagen; 'The Extraction of Cyanides and the Manufacture of Yellow Prussiate by the Davis-Neill Process at the Linacre Gasworks, Liverpool,' by Edward Allen, of Liverpool,

Practical Demonstrations of Interior Lighting.

THE recent article by Dr. Stockhausen, describing the display of shop-window lighting at the "Augur" Exhibition in Berlin* served to illustrate a method of exhibiting the capabilities of sources of light which is coming more and more to the fore. In this exhibition a number of similar shop-windows were illuminated by various methods; the various illuminants, in fact, were exhibited doing exactly what they would be called upon to do under practical conditions, namely, illuminating certain specified objects. Many other displays, on somewhat similar lines, have, of course, been carried out in the past.

At the recent Chicago Electrical Trades Exhibition,* for instance, an "electric home" was fitted up, and a number of different rooms were shown actually illuminated by electric lights, surrounded by suitable shades and reflectors, and exhibits both of gas and electric lighting of this nature are now being shown at the Franco-British Exhibition.



FIG. 1.—KITCHEN.

It is becoming generally understood how very much better it is to show off an illuminant in actual use and to the best advantage rather than to merely exhibit *as* a light and no more. If the public are able to see any system of lighting used in an

* See *Illuminating Engineer*, April, 1908.

interesting way, employed, for instance, to illuminate a tastefully got up living room, they go away with a very much clearer conception of the value of such lights in their own homes than if they are merely shown a row of brilliant sources, arranged like soldiers. At the same time the salesman has an opportunity of educating the consumer to appreciate what he may not previously have had a chance of understanding, the really essential characteristics of efficient and yet tasteful illumination as opposed to mere glare.

This method of procedure seems to have much greater possibilities than are generally realized; it might be extended to many practical problems in illumination, besides house- and shop-lighting, and there are endless possibilities in the way of bringing out the merits of certain types of lamps and fittings, intended to produce special artistic effects.

A specially instructive exhibit might take the form of two identical rooms, side by side, furnished in exactly the same way and lighted by the same illuminant, the illumination being in the one case as efficient and pleasing as care could render it, and all rules

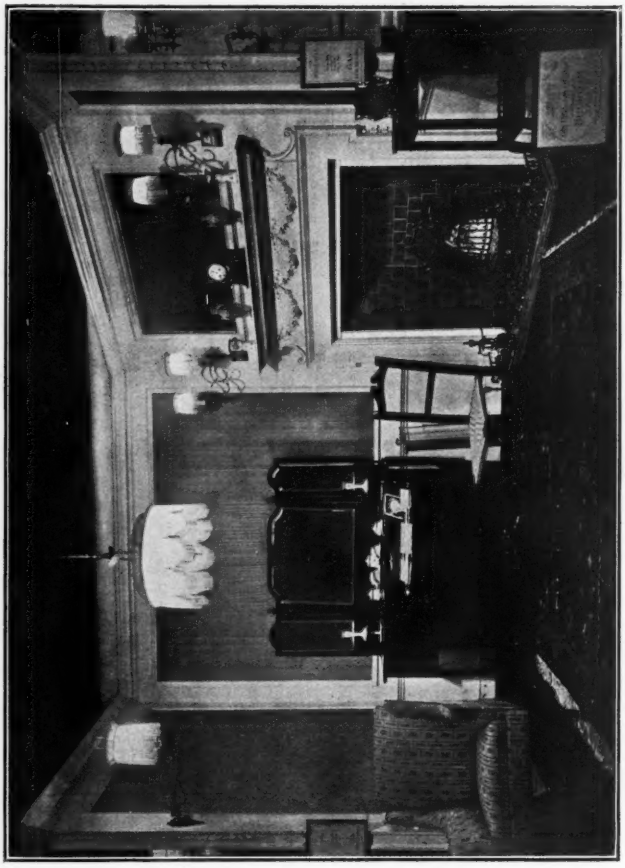


FIG. 2.—BEDROOM.

of good lighting being deliberately disregarded in the other.

It need hardly be pointed out that these considerations are especially important in the case of shop-lighting. The mere production of "glare" has become so usual as to fail in its object of attracting and holding general attention. Moreover, the effort to increase local brilliancy, which was, to some extent, justifiable in the case of our older, comparatively feeble illuminants, becomes tiresome and painful in the case of the most modern types of lamps. The attention of passers by is much more likely to be attracted by some novel and interesting method of arranging the contents of the window.

In this connexion the arrangement adopted at the premises of the Gas, Light & Coke Co., Ltd.—to the courtesy of whom we are indebted for the use of the blocks accompanying this article—in the High Street, Kensington, deserves attention. In these five illustrations an attempt is made to display the actual illumination of five typical interiors, a dining-room,

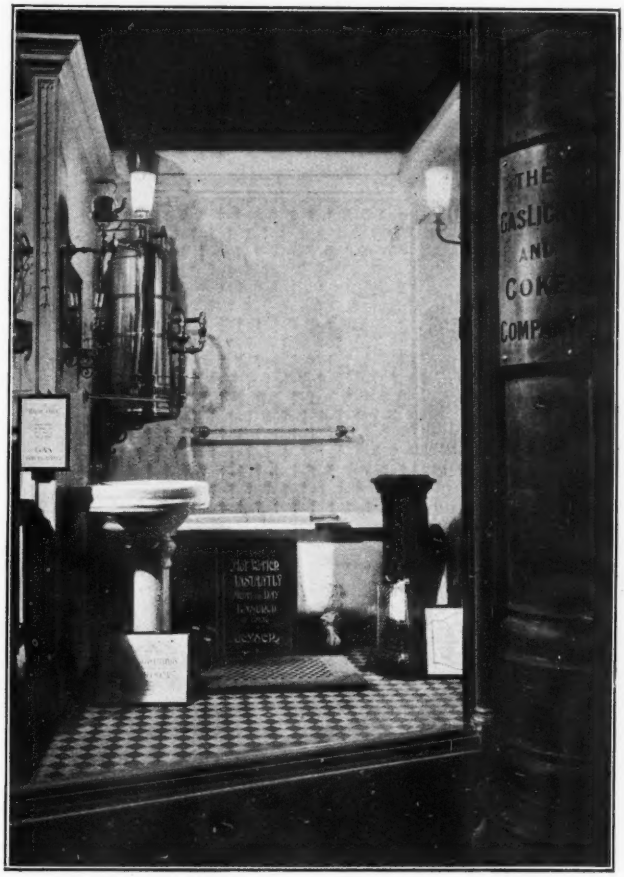


FIG. 3.—BATHROOM.

drawing-room, bedroom, bathroom, and kitchen.

It will be seen that the opportunity is utilized to show a number of different types of fixtures are utilized in the various rooms. Distinct schemes of decoration in the three first rooms named are employed, and in addition the furniture is changed periodically. The lights in the rooms are controlled by pneumatic switches fixed on the back of the partition. Table lamps, equipped with flexible tubes, are also displayed.

Gas fires are installed throughout, and the merits of gas for heating and cooking receive practical demonstration in the bathroom and kitchen.

The illustrations, however, convey a better impression than any description can do as to the advantages of this method of displaying fixtures and lamps, as compared with the mere exhibition of groups of isolated lamps shown burning without reference to their surroundings. In this case it will be seen that somewhat elaborately furnished rooms have been selected, but of course the method is equally applicable to those of a more humble character.

There is indeed a danger that, if too

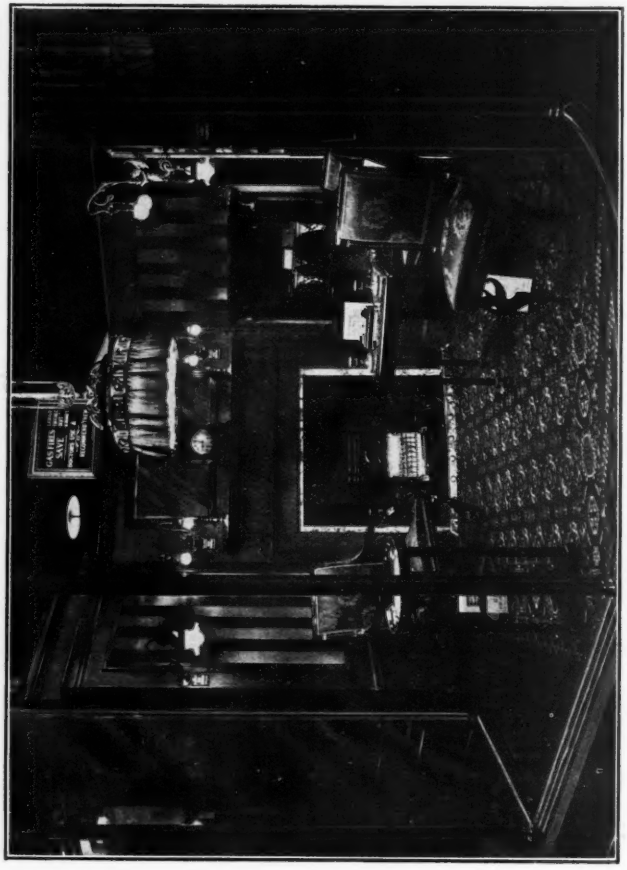


FIG. 4.—DINING-ROOM.

elaborate schemes of decoration and costly furniture are employed, the attractiveness of the latter may overshadow that of the lights employed and so obscure the real intention of the exhibit.

We have in mind one exhibition of the kind in which it is said to have been found necessary actually to remove some of the furniture originally installed, in order to prevent any possible mistake as to the object of the display. What is really necessary is to show the sources of light in actual use under favourable conditions, but at the same time to make the method of illumination the central point of interest.

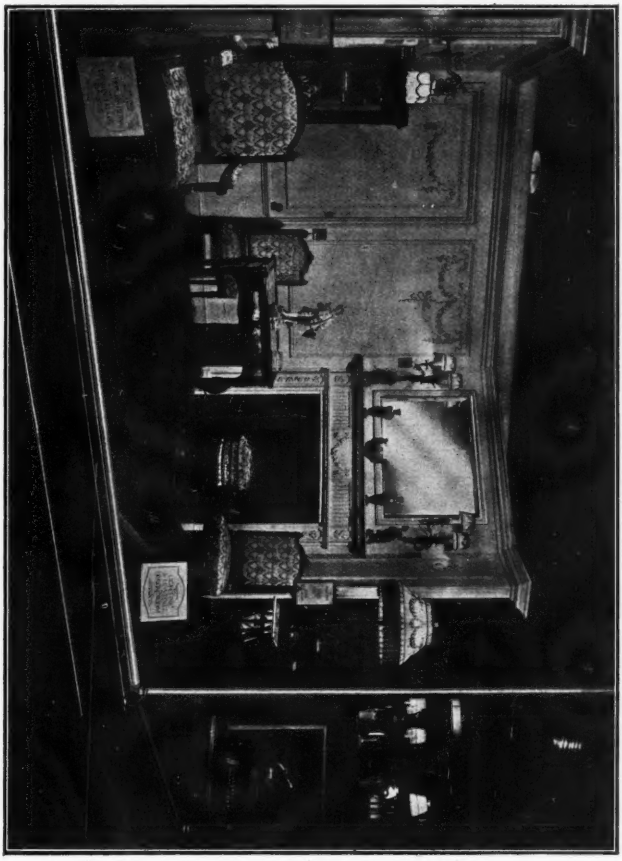


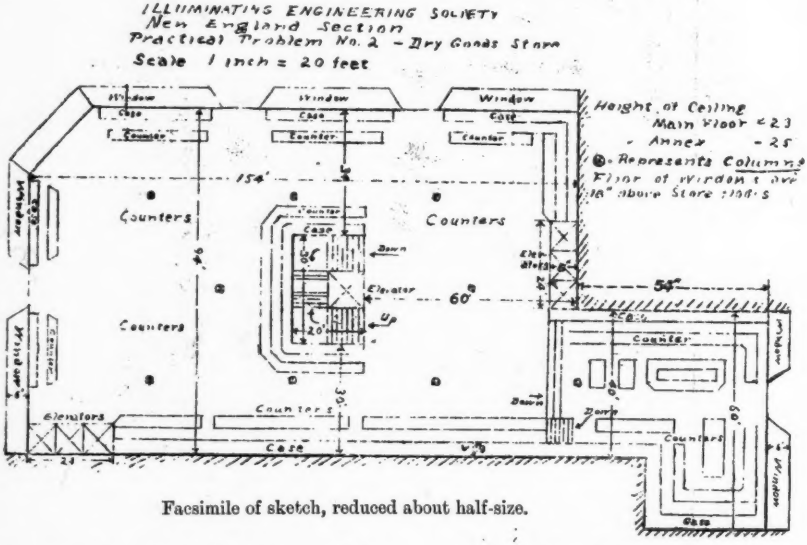
FIG. 5.—DRAWING-ROOM.

Practical Problems in Illuminating Engineering.

We have received a copy of one of the "problem programmes" set by the Illuminating Engineering Society (New England section), which seems to us an admirable illustration of the useful and practical nature of the work now being carried on in the United States.

These problems consist in the circulation of a plan of some interior, which is to be illuminated in compliance with practical requirements, among each method of illumination must stand upon its merits; its advocates may present its advantages, but any misrepresentation must recoil on the heads of those responsible. And those interested have every opportunity of hearing both sides of the question and forming their own conclusions.

We append a facsimile of one of the most recent of these problems, and a copy of the letter by which it was accompanied:—



Facsimile of sketch, reduced about half-size.

the members of the society, and the matter is then thoroughly discussed at a subsequent meeting.

It is quite certain that a discussion of this nature can only result in a better general appreciation of what constitutes good illumination, and, what is equally important, a more perfect understanding as to what the cost of such illumination ought to be. In particular, we should like to draw the attention of our readers to the fact that these problems are discussed by representatives *both of gas and electric lighting*. We have often urged the value of such free discussion in this country. Under these conditions

Illuminating Engineering Society,
New England Section,
May 18, 1908.

Dear Sir,—The May meeting of the New England Section of the Illuminating Engineering Society will be held at the Auditorium of the Edison Building, 39, Boylston Street, at 7.30 on Wednesday, May 27.

The problem presented for solution at the last meeting proved very interesting, and a second problem has accordingly been arranged for the May meeting. A plan is enclosed of a dry goods store to be lighted. The solutions will be worked out and presented as at the last meeting, by representatives of gas and electric interests.

Very truly yours,
R. C. Ware, Secretary.

Gas-Lighting at the Scottish National Exhibition, Edinburgh.

By W. R. Herring,
Chief Engineer to the Edinburgh and Leith Corporation's Gas Commissioners.

(*Continued from p.* 484.)

When the statement of tests of various lamps used at the Edinburgh Exhibition were published a few weeks ago, I was not able to include amongst them the tests of the Vesta-Graetzin high-pressure inverted lamp, which, through the instrumentality of Messrs. Falk, Stadelmann & Co., London, I had arranged to erect at the Exhibition, owing to their not having come to hand in time.

The lamps in question are, I understand, exactly the same as those at present being largely put up in the streets of Berlin. The lamp itself appears to be a simple adaptation of the Graetzin lamp to high pressure purposes, and differs in this respect from the Keith-Blackman lamp, which takes the fullest advantage of the pre-heating of the gas and air prior to combustion by abstracting from the products of combustion some of their escaping heat. The lamps to be installed consist of two two-mantle lamps and one three-mantle lamp. The effective size of the mantle when inflated with the flame is $3\frac{1}{2}$ in. by $1\frac{3}{4}$ in.

Over 5,000 candles of illumination from a single lamp in size no larger than an electric arc-lamp is certainly a high degree of illumination to disperse from one centre, and without discussing the question as to whether high-power light centres are the best for general illuminating purposes, it does certainly appear as though we were approaching the time when workshops and warehouses would be as brilliantly or even more brilliantly lighted by artificial means than they are at present with ordinary daylight. It will be observed that the candle-efficiency per foot of gas is not so great in these lamps as in the Keith-Blackman lamp, and I attribute this entirely to the fact that the pre-heating of the gas and air supplies in these lamps is accomplished only in its passage through the pipes

Photometrical Tests on Messrs. Falk, Stadelmann & Co.'s New High Pressure Inverted Lamp—3 Mantle Light, Mantle $3\frac{1}{2}$ inches long by $1\frac{3}{4}$ inches diameter, slight cone shape.

The normal quality of the gas would be 20 to 21 candles when burned in a No. 2 Metropolitan Argand Burner, and the calorific power of the gas at the testing station 526·4 net.

The test was taken by a Simmance & Abady's Street Photometer, which had been previously verified by testing a given lamp simultaneously on a 100-inch Bar Photometer and the Portable Photometer in the same room and under like conditions.

13th May, 1908.

Pressure Inches.	Height of lamp from floor.	Distance of lamp from Photometer Disc.	Angle.	Feet Candles at Photometer disc.	Consumpt feet per hour.	Candle-Power.	C.-Pr. per feet.
	ft. in.	ft. in.	°				
61	4 8	49 5	4	1·7	89·4	4,154	46·5
61	16 0	50 8	16	1·8	89·4	4,666	52·2
61	20 0	52 1	21	1·9	89·4	5,174	57·9
61	28 0	47 6	34	2·1	89·4	4,716	52·7

Remarks.—Clear globe. The first test (viz., at angle of 4°) is as nearly horizontal as possible without cutting off light with shade. The last test (viz., as near angle of 45° as possible).

leading to the burners, whereas in the Keith-Blackman lamp this is a special feature of the construction of the lamp, and is brought about by causing a momentary pause or delay in the flow of the gas and air in a large chamber immediately in the full way of the exit flue from the lamps.

Another point of importance to note is that on the horizontal line the three-light lamp gives a lower efficiency per foot of gas than the two-light lamp. This can only be accounted for by the fact that the third mantle is partially shadowed or shielded by the other two.

In view of the visit of the Institution of Gas Engineers to Berlin, where I understand some of these lamps will be seen lighting the highways, it will be interesting to add these tests to those already published.

PHOTOMETRICAL TESTS ON MESSRS. FALK, STADELMANN & Co.'s NEW HIGH PRESSURE INVERTED LAMP—2 MANTLE LIGHT, MANTLE 3½ INCHES LONG BY 1¾ INCHES DIAMETER, SLIGHT CONE SHAPE.

The normal quality of the gas would be 20 to 21 candles when burned in a No. 2 Metropolitan Argand Burner, and the calorific power of the gas at the testing station 545·9 net.

The test was taken by a Simmance & Abady's Street Photometer, which had been previously verified by testing a given lamp simultaneously on a 100-inch Bar Photometer and the Portable Photometer in the same room and under like conditions.

14th May, 1908.

Pressure Inches.	Height of Lamp from Floor.	Distance of Lamp from Photometer Disc.	Angle.	Feet Candles at Photometer Disc.	Consumpt Feet per Hour.	Candle-power.	Candle-power per Feet.
	ft. in.	ft. in.	°				
61	4 0	40 4	4	1·75	53·0	2,829	53·3
61	16 0	42 3	20	1·70	53·0	3,037	57·3
61	20 0	43 6	25	1·65	53·0	3,117	58·8
61	28 0	37 6	43	1·87	53·0	2,658	50·1

Remarks.—Clear globe. The first test (viz., at angle of 4°) is as nearly horizontal as possible without cutting off light with shade. The last test (viz., as near angle of 45° as possible).

Publications Received.

WE have received a bound copy of *Traité théorique et pratique de la Fabrication du Gaz*, by E. Borias (Paris, Librairie Polytechnique Ch. Beranger), a scientific treatise on the production of gas, to which we mean to refer in greater detail in a subsequent number.

Also *Les Nouveaux Modes d'Éclairage Électrique*, by A. Berthier (Paris, H. Dunod et E. Pinet). This volume, detailed examination of which we likewise postpone to a subsequent issue, discusses the different modern methods of electric lighting, including arc, electric, and mercury vapour lamps.

We have also to acknowledge the receipt of the beautifully illustrated number, (Vol. II.) of the *Annals of the Astrophysical Observatory*, issued from the Smithsonian Institute, U.S.A.

SPECIAL SECTION.

The Recent Augur Exhibition of Display-Window Lighting in Berlin.

A Description of some modern sources of light and their application to show-window lighting.

By W. Biegon von Czudnochowski.

At the present time we observe everywhere the prevailing tendency to make things beautiful. This tendency is well illustrated by modern methods of arranging display-windows; on the taste and ingenuity expended upon the arrangement and lighting of the goods in a window depend their general attractiveness to the passing customer.

This question of shop-window illumination formed the subject of special study at the recent "Augur" Exhibition in Berlin.* For this purpose a number of windows were erected all of exactly the same dimensions: 3 metres wide, 1·5 metres deep, and 3·5 metres high, as shown in Fig. 1.

Those taking part in the display were required to illuminate the window at a cost of 500 mk.; the variety of lighting adopted was optional, it being, however, stipulated that only one system should be used in the same window. The nature of the goods displayed was also left to the choice of exhibitors, who were therefore in a position to adopt the variety of goods best suited to the type of illuminant they proposed to utilize. In calculations of the running costs of installations, the price of electricity was assumed to be 0·4 mk. per unit and the price of gas 0·13 mk. per 1,000 litres. It was further enacted that the general scheme of illumination must be of a thoroughly up-to-date, practical nature, and that data as to the costs of maintenance should be exhibited in each window, the firm exhibiting being, of course, responsible for the correctness of these figures. It must be added, however, that, the authorities having eventually

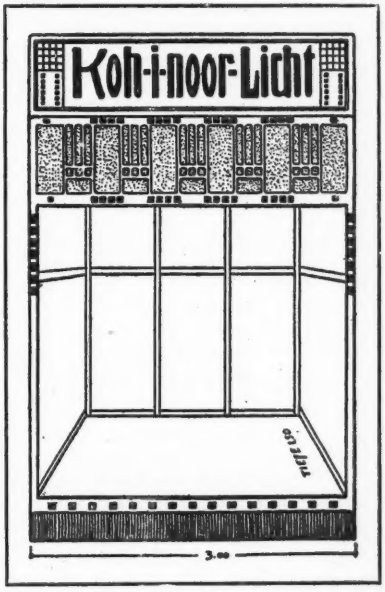


Fig. 1.

decided not to award any prize in connexion with the display, the regulation insisting upon the exhibition of data as regards, costs, &c., was afterwards relaxed. Eighteen such windows were erected, and illuminated by the following firms:—

* See *The Illuminating Engineer*, April, p. 289.

The ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT (Berlin), the BAYERISCHE GLÜHFADEN FABRIK, Lechhausen, the CARBONE-LICHT GES. (Berlin), EHRICH & GRAETZ (Berlin), FRISTER & Co. (Niederschöneweide, Berlin), J. HIRSCHHORN (Berlin), KLATTE & Co. (Hamburg), LION & TUGENDHAT (Berlin), the REGINA BOGENLAMPENFABRIK (Cöln-Sülz), the SIEMENS-SCHUCKERT-WERKE (Berlin), the STARK LICHT GES. (Berlin), the VIEL-LICHT-GES. (Berlin).

Among other firms who exhibited, but who did not take any direct part in this competition may be mentioned the BECK BOGENLAMPEN GES. (Frankfurt a-Main), the DEUTSCHE GAS-GLÜHLICHT GES. (Berlin), KÖRTING & MATHIESEN (Leutsch, Leipzig), A. MEENEN (Berlin), K. WEINERT (Berlin).

The methods of lighting adopted may be considered separately under the headings of gas lighting, lighting by electric glow-lamps, and lighting by arc-lamps.

I. SYSTEMS OF GAS LIGHTING.

(*a*) Practically all modern methods of gas lighting involve the use of mantles; the most recent forms of lamps utilize inverted burners, of

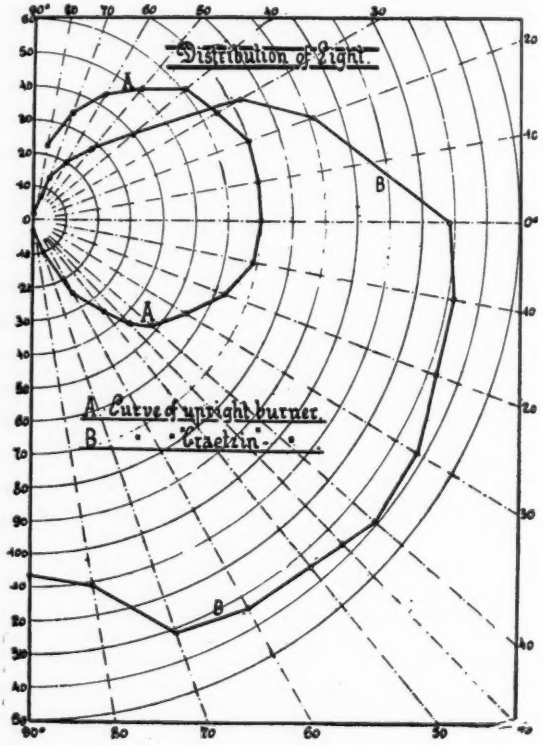


FIG. 2.

which the *Graetzin-Light*, manufactured by EHRICH & GRAETZ according to the *Mannesmann* patents (D.R.P. 126,135) is a well-known example.

A number of these lamps have recently been installed in the streets of Berlin. The system can be employed in conjunction with either high or low pressure of the order of 23 to 75 mm. The admission of gas and air is under

full control, while special precautions are also taken to prevent the possibility of the flame lighting back. Such a lamp, yielding about 110 H.K. in a horizontal direction, will consume 87–90 litres of gas. The nature of the distribution of light will be understood from Fig. 2.

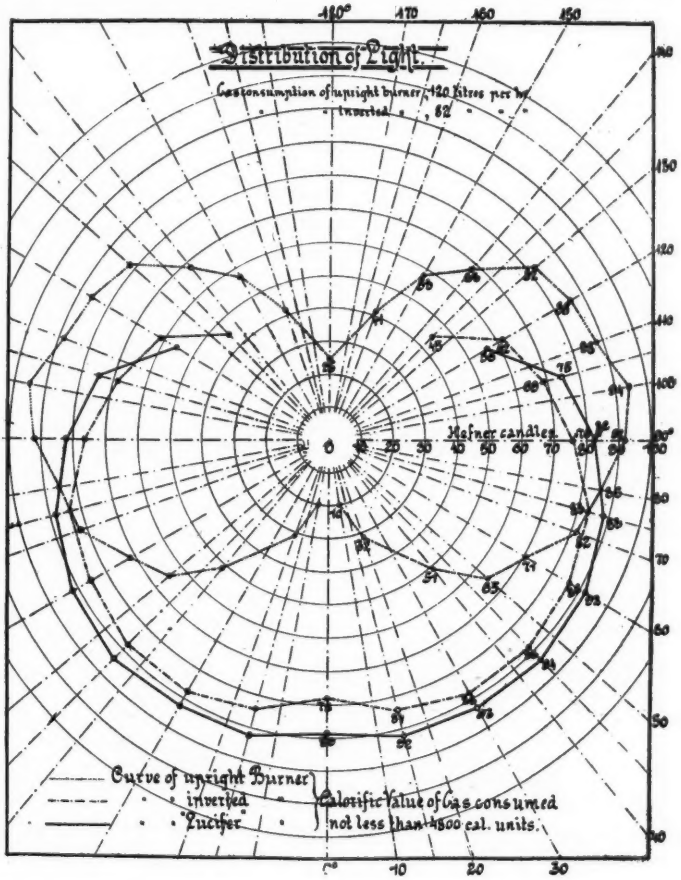


FIG. 3.

A similar form of lamp is the *Lucifer* type of R. FRISTER A. G., in which the absence of any chimney is worthy of note. This lamp yields an intensity of 90–120 H.K., with a consumption of 80 litres per hour. The nature of the distribution of light is shown in Fig. 3.

Other inverted lamps exhibited were the *Eros*, the *Saerular*, and the *New Auer Light*. The *Eros* light of J. HIRSCHHORN burns at a pressure of 23 mm., and the lamps can be arranged to include 1 to 5 mantles. The chief characteristics of the *Saerular* light are the horizontal outlet pipes, and the absence of any chimney, very complete combustion, at a pressure of 15 mm. being guaranteed. A single mantle yields about 120 H.K., with a consumption of 85–90 litres per hour. As many as 9 mantles, however, are placed in a single lamp, yielding in all 1,140 H.K. at a consumption of 800 litres of gas per hour.

Several varieties of the *New Auer Light* for indoor illumination are available, all utilizing a single mantle. The number of mantles may be increased for out-door lighting. The minimum pressure is in this case 28 mm.

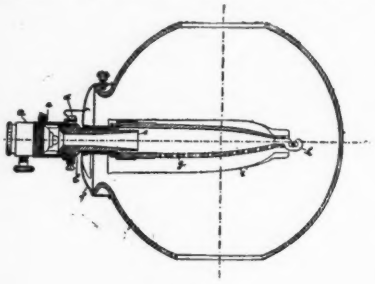


FIG. 4.

The mantles are comparatively small in size. The gases coming from the mantle pass out through two special chimneys, the lighting of the burner being carried out automatically by means of the special *Harras* device. Lamps intended for external illumination are made specially rain- and wind-proof, to guard gainst possible extinction of the pilot-flames utilized with them. When a single glass chimney is utilized with several mantles, a single pilot-flame can serve to light up all the group. According to the tests of the Reichsanstalt these lamps yield an intensity of about 110 H.K. with a consumption of 91 litres of gas per hour.

An entirely new type of lamp of exceptional interest is the *Tubus* burner of R. FRISTER, in which a horizontally placed mantle, arranged as shown in Fig. 4 is utilized.

Here *a* is the entrance gas-pipe terminating in the mixing tube *b*; *e* serves to regulate the air-supply. The globe *k* is held in position by *f*; *g* is the porcelain burner—the "tubus," with the small magnesia-hook *h*, and the mantle *i*. The flame is so arranged as to heat the horizontal mantle over its entire length, though naturally all portions do not appear equally bright. Instead of a clear or obscured globe, a special reflector is commonly utilized. The arrangement shown in Fig. 5 is specially intended for shop lighting, where the distinctive characteristic of a horizontal mantle is specially valuable.

The nature of the curves of distribution of light will be understood from Figs. 6 and 7.

In this interesting new system both the primary stream of sucked-in air, and the secondary air admission, are greater than in the case of the inverted burner. This is accomplished both by the absence of any marked upward draught and by the position of the mantle with respect to the air-inlet. As a result such lamps burn without a trace of smoking on a pressure of about 20 mm.

(*b*) In gas-lighting, as in other branches of illumination, there is very general tendency to demand "more light," and consequently a tendency to concentrate a great intensity in a single source of light.

This was formerly accomplished by mounting several mantles in the same globe, but the same end may be attained in another way, namely by increasing the dimensions of the mantle, and at the same time using correspondingly greater flames to bring them to incandescence. Apart from this we can also secure better results by making the flame-temperature higher.



FIG. 5.

P. Lucas, ten years ago, had already discovered that the most perfect mixture of gas and air for this purpose was in proportion of one (by volume) of gas to six of air. In order to reach this condition the plan has been adopted of driving gas into the burner under pressure, and thus sucking in a

correspondingly higher proportion of air; this method is exemplified in the *Graetzin* light, of the VIEL-LICHT GES.

Another method of obtaining the same result involves the admission of a supply of compressed air to the lamps, as occurs in the *Pharos* light of KLATTE & Co. of Hamburg. The *Pharos* system, it may be remarked, really makes use of *both* methods, utilizing both compressed air and gas at a pressure of 1,300 to 1,400 mm. of

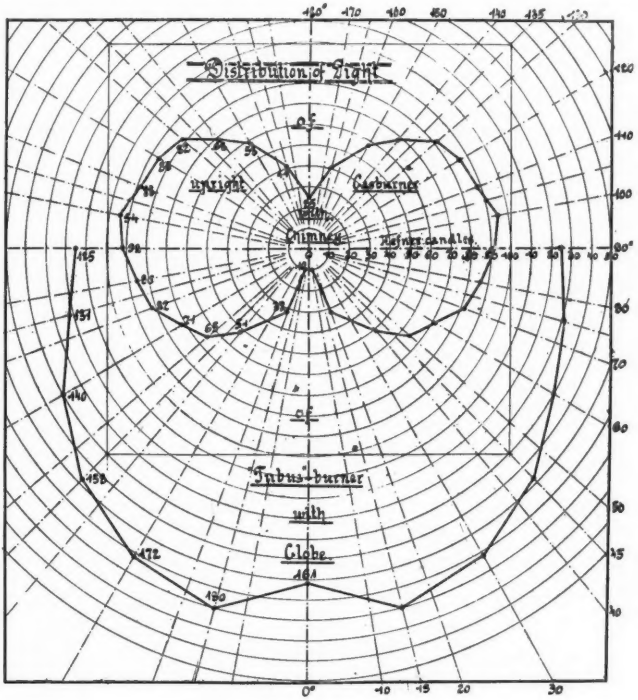


FIG. 6.

water. Both methods, however, demand special apparatus and arrangements, the latter even requiring a separate system of pipes for the conveyance of the compressed air. The most perfect solution of the problem would entail the design of a lamp which could be used on the existing pipes only, and generally would not require any further complication beyond the ordinary gas supply. This has been attained in the *Lucas Compressor* light of the STARK-LICHT GES.

The general nature of this ingeniously constructed lamp will be gathered from Fig. 8.

In order to obtain the desired proportions of gas and air, Lucas originally had recourse to long chimneys placed above the lamp. It was found, however, that the intensity could not be increased above about 500 H.K. without making the chimneys supplying the forced draught unduly long. He therefore constructed lamps in which the suction-effect was obtained from small hot-air motors fixed above the mantle. But these motors, unfortunately, were found to deteriorate with use.

Finally the construction shown is Fig. 8 was adopted. The gas enters through the regulator at *r*, passes through the cock *h* into the mixing

chamber *m*, and finally through the burner at *n*, and so, after heating the mantle, up the chimney. In this is fixed the thermopile *t*, the current generated in which is carried by the wires p_1, p_2, p_3, p_4, to *m*, a small electro-motor, rotating about a vertical axis at a speed of 2,000 revolutions a minute. This motor is coupled directly on to a small fan, which creates the required draught. It is interesting to note that the lamp is an example of two great rivals, gas and electricity, acting in harmony. The height of the entire lamp is about 1 metre, and the diameters of the globe and reflector 0·4 and 0·65 metre respectively.

The lamps are rain- and wind-proof, and yield about 1,250 H.K. at a consumption of 1,000 litres of gas per hour.

Table I. gives some figures as to the relative costs of the various installations: the absence of any complete data as to the actual illumination of the display as a whole must, however, be regarded as an unfortunate omission on the part of exhibitors. Gas lighting was employed for the illumination of windows containing goods of very diverse character—for instance, hardware, linen, and silk goods, flowers, jewellery, &c.

The colour of the light emitted was practically the same in the case of all

TABLE I.

	Specifications.	"Eros." T. Hirschhorn.	"Pharos." Klatte & Co.	"Lucas." Stark Licht. G.m.b.H.	"Graetzin." Viel Licht. G.m.b.H.	"Graetzin." Ehrich & Graetz.
I. Initial Cost.	(*a*) A one-burner lamp for interior lighting ...	8·0[1]	70·0	...	6·0[4]	6·0[4]
	One lamp for external lighting	40·0	80·0	250·0	57·0	57·0
	One ceiling lamp	...	...	...	50·0	...
	One lamp mounted on wall of interior	70·0	...[3]	...	...	86·0
	(*b*) The whole installation ...	300·0	(2 + 1)230·0	(2)500·0	514·0	914·0
II. Wording Expenses.	(*a*) Consumption of 1 lamp or burner	90 lit.	0·065 & 0·12	0·13	90 lit.	90 lit.
	(*b*) Consumption of all inside lamps	1·71m.[3]	0·25	0·26	0·12	0·12
	(*c*) Consumption of all outside lamps	0·6m.[3]			0·06	0·06
III. Costs of supply per 1,000 burning hours.	(*a*) For 1 lamp inside window	1 mantle	0·05	0·14	0·30	0·30
	For 1 lamp outside window...	...	0·12			
	(*b*) For the whole installation	1 mantle	0·22	0·28	4·20	5·0
IV. Method of lighting-up.	(*a*) System	electric[2]	electric	by pilot flames	...	electric also for automatic extinction
	(*b*) Costs for 1 lamp... ...	5·50[2]	20·0			
	(*c*) Costs of the whole installation	104·50[2]	60·0			

[1] Complete with surrounding hanging glass rods for the dispersion of light.
[2] Without costs of installation and battery.
[3] Additional costs of complete apparatus for air compression, electrically driven, with motor, 1,100 marks.
[4] Small burners are also supplied for this type, complete, price 5 marks.
All prices are given in marks.

the lamps to which reference has been made, and though, as explained above, many different classes of goods were illuminated, the colours could, apparently, always be distinguished satisfactorily.

arranged in straight lines parallel to the window-front, in others lamps were mounted at intervals on the walls of the shop. In yet other cases a few powerful lamps were placed outside the window.

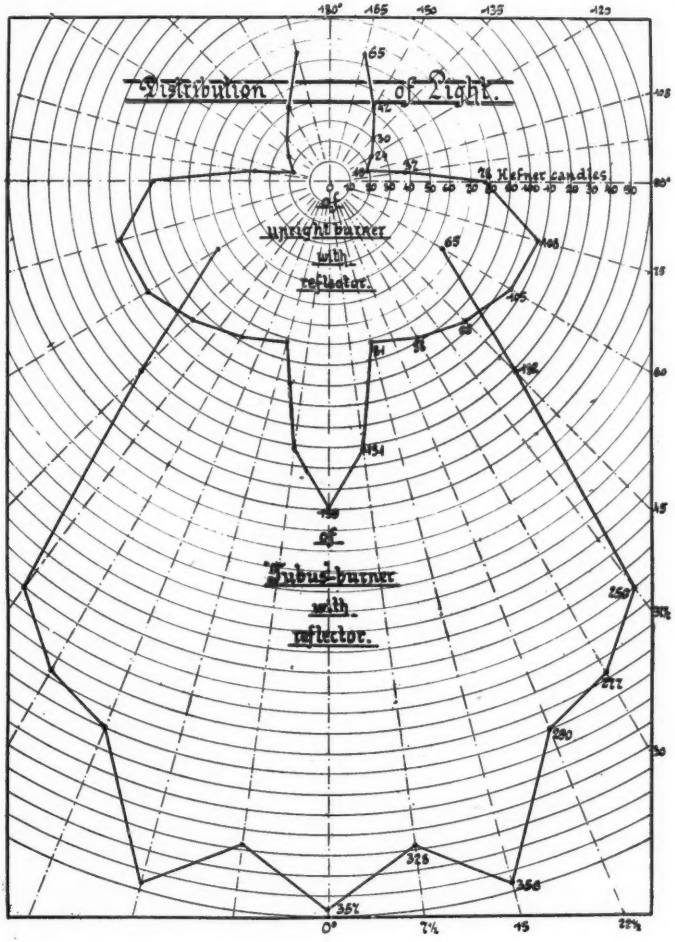


FIG. 7.

The different arrangements of the lights adopted illustrates the range of intensities now available, and the general flexibility of this system of lighting. Lamps varying in candle-power from 50 up to 1,500 were exhibited. In some cases lamps were

Special interest attaches to the systems of automatic lighting up exhibited, for, in the case of large establishments the lighting up of all the individual lamps in succession, one at a time, is distinctly inconvenient. On the other hand the increased cost

of installation involved is not very great, considering the advantage to be derived as a result.

It may be remarked that the use of electrical ignition devices is another example of the two rivals—gas and electricity—working together to accomplish a desired result.

In what follows, therefore, we can afford to pass over the carbon lamps, and refer mainly to more recent types exhibited.

Mention may first be made of the forms of Nernst lamps exhibited by the A. E. G. Three distinct types of these lamps are now manufactured,

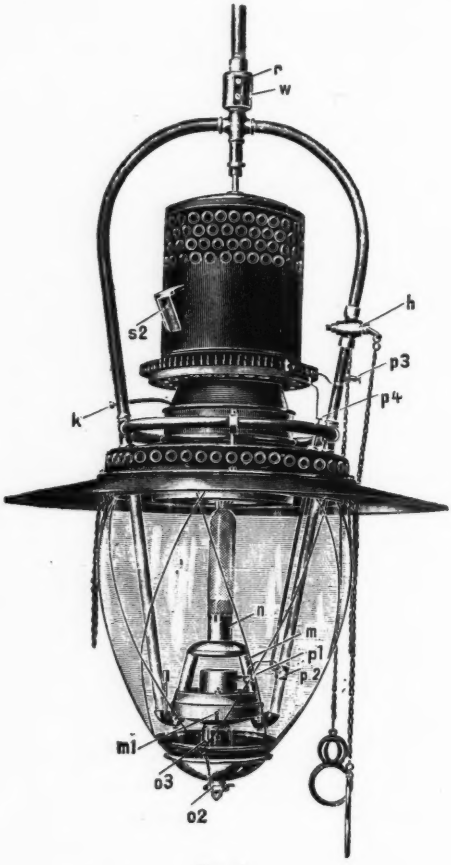


FIG. 8.

II. ELECTRIC GLOW-LAMPS.

When walking in the streets one cannot but be impressed with the fact that the carbon filament lamp has all but disappeared; they have either been replaced by metallic filament glow-lamps or the small arc-lamps of recent introduction.

the B lamps, with horizontal glowers taking 0·25 to 0·5 ampères, and yielding 16 to 35 H.K., the larger A type, with vertical glowers, taking 1 to 2 ampères, and yielding 68 to 250 H.K., and the *Intensivlampe*, in which a set of carbon filament lamps are mounted in addition to the Nernst filament. These light up immediately the lamp

is switched on, and are afterwards cut out of circuit when the Nernst filament lights up. The Nernst lamp consumes about 1·5 watts per H.K. The D.C. Nernst lamps must always be placed in the holder in such a way as to preserve the correct polarity; otherwise electrolysis results in the deposition of metallic magnesium on the kathode, which is subsequently oxidized, and results in the heaping up of material, and, ultimately, the destruction of the filament.

The *Osmium* lamp of AUER VON WELSBACH now consumes about 1 watt per H.K.; this lamp has already been described by Dr. H. Weber (*Illuminating Engineer*, No. 4, p. 297–301).

The consumption of the well-known and ingenious *Tantalum* lamp of MESSRS. SIEMENS & HALSKE, varies from 1·5. watts per H.K. to the higher value of 2·3. watts per H.K., in the case of the more recent type referred to by Dr. Weber (*ref. cit.*). These lamps are manufactured for pressures up to 120 volts, with a life of 800 to 1,000 hours. They are, however, subject to the drawback of not burning well on an alternating current circuit. Some of these lamps, equipped with a new type of fixture, are shown in Fig. 9. A similar arrangement, specially intended for shop lighting, is shown in Fig. 10. These lamps are made in three forms, A and B, yielding 12–25 and 32–50 H.K. respectively, and consuming 1·5–1·7 watts per H.K., and C, yielding 8, 10, or 16 H.K., and running at 2·1–2·3 watts per H.K.

The *Osram* and *Osmin* lamps, introduced in Germany and Austria respectively by the AUER COMPANIES, both involve the use of filaments of tungsten. The osram lamp (according to the tests of the Reichsanstalt) consumes 1 watt per H.K., and has a life of more than 1,000 hours, on the average, accompanied by a loss in candle-power of only 4 per cent. Three distinct forms of these lamps are also made: (1) For burning in parallel on 100–130 volts, yielding 25, 32, 50, and 100 H.K. respectively. (2) For series burning on 100–130 volts per lamp, and yielding 24, 26, 28, 30, 34, 36, 48, 52, and 54 H.K. (3) Low voltage lamps for use with accumulators on motor cars, railway carriages, &c.

As an illustration of the economies



FIG. 9.

that may be achieved by the use of osram lamps, the company quote the following example:—

Assume the price of a kilowatt-hour to be 0·5 mk., and the carbon filament lamp and the osram lamp to take 3·5 and 1 watt per H.K. respectively. The watts consumed by a 32 c.-p. lamp will be 112 and 32 respectively. Therefore, during a single year, which corresponds roughly to 1,000 burning hours, 30 lamps would consume 3,360 and 960 K.W. hours respectively. The number of lamps required will be 48 and 30 respectively, and the cost of a lamp being 0·5 mk. and 3 mk. respectively, the total cost during the year will amount to 1,704 mks. and 570 mks. in the two cases. We should therefore save 1,134 mks. during the

year. The interest on the original price of 3 mks. would thus be paid off in the first 75 burning hours.

Unlike the tantalum and osmium lamps, the tungsten lamps could at first only be burned in a vertical position, for the adoption of the method of supporting the filament by winding it on a frame, was excluded by the patent of SIEMENS & HALSKE. More recently, however, lamps up to



FIG. 10.

50 H.K., capable of burning in any position, have been manufactured, and sold at an additional cost of 20 pfennigs each.

Another metallic filament lamp is manufactured according to the patents of Drs. Just and Hanaman of Vienna, and is made by the BAYERISCHE GLÜHFÄDEN FABRIK of Lechhausen (Bavaria). This, too, consumes about 1 watt per H.K.

Similar lamps to those already described are sold by the A. E. G. and the BERGMANN ELEKTS. GES., both of Berlin.

Among other metallic filament lamps now in practical use may be mentioned those of J. PINTSCH in Berlin and KREMENEZKY in Vienna, who work the patents of DR. KUZEL covering the use of rare metals in a colloidal condition.

GÜLCHER, of Berlin (D.R.P. 145,456, 145,457), also makes low-voltage iridium lamps intended for use on accumulators, and consuming 1·0 to 1·5 watts per H.K.

Zirkon lamps utilizing zirconium carbide, have also been constructed by HOLLEFREUND & Co., of Berlin, according to the German patents 133,701, 137,568, and 137,569, (Sander) and 140,323, 140,378, 141,353, 146,555, 147,233, and 147,316. According to

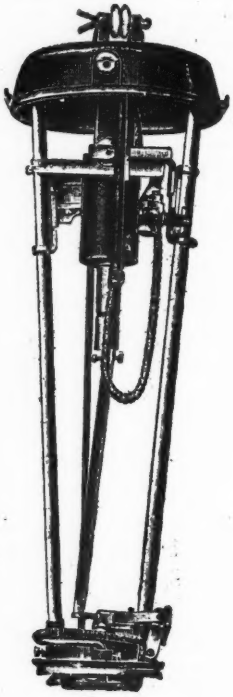


FIG. 11.

Wedding the original *Zirkon-lampe* consumed 2 watts per H.K. Subsequent modifications, or *Zirconium-carbon* lamps gave 30–32 candle-power at a consumption of 2·5 watts per H.K.

The latest improved form of zirconium lamp is due to BOJE, who, under the best conditions, secured a consumption of 0·3 watts per H.K., while a life of 1,000 hours was found possible coupled with a consumption of

1·0 watt per H.K.; during the first 500 hours the candle-power remained practically constant. Allowing a diameter of 0·6 mm., filaments so manufactured must be 55 cms. long for 110 volts, and lamps for this pressure require three single loop-filaments mounted in series.

Table II. shows the relative costs of the lamps which were exhibited at the Augur Exhibition.

Here again one feels that the absence of any complete data as to the actual illumination of the windows as a whole is unsatisfactory. Electric lighting by means of glow-lamps was utilized for 5 show-windows, and these again contained a very varied selection of goods. The illuminated windows contained leather work, boots and shoes — especially *white* shoes — linen goods, electric heating and ventilating apparatus, &c.

The whiter light yielded by the new glow-lamps, as compared with the old carbon filament ones, is a distinct advantage for shop lighting, where the ability of a light to bring out delicate shades of colour is often of paramount importance. The colour of the light yielded by them does not differ very greatly from that of the modern incandescent mantle, so that both can be utilized for the conditions, as far as the display of colour is concerned.

Here again as in the case of gas lamps, we have only recently succeeded in producing lamps which can be burnt in any position. The older gas mantles were necessarily burnt in a vertical position. To-day we have the inverted burner, in which the position of the mantle is reversed, and the *Tubus* burner, which even burns in a horizontal position. With the exception of the tantalum lamp, the earlier metallic filament lamps likewise suffered under the disadvantage that they could only be utilized vertically, but this difficulty may now be said to have been overcome.

Naturally, for shop lighting this last quality is very essential, for in order to secure the most perfect effects we wish to be able to place our sources wherever they may be desired and in a vertical, horizontal, or slanting

TABLE II.

		Siemens & Halske Tantalum lamps.	Siemens & Halske Tantalum lamps.	A. E. G. Nernst lamps B	Bayer. Glühfaden Fabrik Just-Wolfram lamps.	A. E. G. Metallic Filament lamps.	Lion & Tugendhat. Bergmann metall. filament lamps.
I. Initial cost of Installation.	(*a*) For one lamp	Marks. 2·5	Marks. 3·0	Marks. 13·65	Marks. 5·00[4]	Marks. 3·00	Marks. 3·00
	(*b*) For the whole installation	45·00	80·00	111·80	30·00[5] 60·00[6]	279·0	240·00
II. Cost of energy per hour.	(*a*) For one lamp	0·0102	0·032	0·088	0·024	0·022	0·01
	(*b*) For the whole installation	0·12	0·256	0·704	0·480	0·040	0·24
III. Costs of Renewal for 1000 hours.	(*a*) For one lamp	2·5	3·00	4·00[3]	5·00	3·00	3·00
	(*b*) For the whole installation	30·00	24·00	32·00	100·00	54·00	72·00

[1] Two brackets carrying 12 lamps and fixtures.
[2] Ceiling illumination, 8 lamps, total intensity, 400 H.K.
[3] For 1 burner only: as is well known the *burner* only is replacable in these lamps, exactly as are the carbons in the case of arc lamps.
[4] Intensity of each lamp, 50 H.K.
[5] Two boxes carrying 5 lamps each, placed vertically on sides.
[6] Two boxes each carrying 5 lamps, placed horizontally on top, all costs reckoned in marks.

position as circumstances may require.

In these cases lamps hanging from the ceiling or mounted on wall-brackets, or arranged in cascade as shown in Fig. 9, were utilized. Some of the best effects, however, were secured by mounting the lamps in the manner of footlights in a theatre, either at the base, top, or sides of the window. Indeed a shop window may be said actually to represent a miniature stage, the people out on the pavement being the spectators, and it is natural that the methods which have proved most effective in the theatre should prove of value in this case also.

Electric Arc-Lamps.

The introduction of the differential arc-lamp only occurred in 1879, but the simple electric arc between two carbons was known long before, as far back as the experiments of Davy, and of Deleuil, who for the first time undertook public illumination by this method in 1844. In all such cases two vertical and co-linear carbons were employed; many other varieties and shapes of carbons were, of course, attempted — cylinders, plates, discs, &c.—but none found their way into practical use.

In 1898, however, Bremer began his experiments on this subject, experimenting in a comparatively new field, and using carbons of a variety which have since proved of the greatest practical use, and which I have classified as "electrodes of the second order."* These form the basis of the so-called "flame" or "chemical" carbons of to-day. Bremer's success was due to the fact that he not only applied the results obtained by earlier workers in this field, but added devices of his own contrivance. As a result he eventually brought out carbons yielding light of some special spectral composition, and at a vastly more efficient rate than previously. His carbons were distinguished both by the characteristic yellow light they gave and the unusual length of arc adopted.

A special company, the Deutsche Gesellschaft für Bremerlicht, was formed to exploit his inventions, and other German firms were soon forced to co-operate. In a short time a number of flame-arcs came into use, all, however, possessing the same radical characteristics as the Bremer arc. This revolution in methods of arc-lighting may be said to have commenced at the beginning of the new century in 1900. The old system of vertical carbons is now being completely replaced by carbons of the inclined variety, both for flame carbons and for the ordinary kind. The new system of inclined carbons has not only enabled a higher P.D. to be employed across the arc—a distinct advantage when the loss of pressure in additional resistance on many circuits is borne in mind—but has also resulted in improved efficiency, due to the avoidance of the loss of light occasioned by the lower negative carbon and a greatly improved distribution of light.

Another kind of improvement in arc-lamps followed the Bremer type of arc-lamp. In 1894 to 1895 Niewerth of Berlin tried to manufacture arc-lamps intended for small currents of 1 to 2 amperes. However, he met with but small success, partly because, in the case of an open arc-lamp such as he employed, the area of cooling surface was too great in proportion to the small currents employed. Steadiness in an arc-lamp is only attainable when a comparatively high temperature can be maintained especially in the neighbourhood of the crater.

The problem of the small-current arc-lamp was finally solved by A. Rignon in 1902, and subsequently by Siemens & Halske, who introduced the *Lilliput* arc in 1903. These two lamps were followed by a succession of others of the same general nature, the *Mignon*, *Miniatur*, *Perkeo*, *Piccolo*, *Lupa*, *Regina*, *Baby*, &c., lamps, as they were termed according to the nomenclature of the countries in which they were brought out. All these

* 'Verhandl. deutsch. physikal. Gesellsch.' 5, 157 to 176, 1903; 'Das elektr. Bogenlicht s. Entwickelung u. s. physikal. Grundlagen,' p. 468, &c., 1904-1905.

lamps employed currents in the neighbourhood of 2 to 3 amperes. The explanation of this success lay in the reversion to a form of small arc-lamp, of such dimensions as to avoid the excessive cooling of the electrodes that had proved detrimental in the case of the earlier lamps. In these lamps the old form of vertical and co-linear carbons has been universally adopted.

Another type of lamp, intended to be intermediate between the ordinary open and enclosed arcs, was the so-called *Economy* lamp (Sparlampe). In these lamps the admission of air to the electrodes was limited, and carbons of relatively small diameter were employed. As a result the advantages of both open and enclosed lamps were obtained in some measure. The range of current for which they are made is in the neighbourhood of 4 to 5 amperes; lamps of this kind are built by most important modern firms of the present day.

Having dealt briefly with the recent history of the arc-lamps, let us now turn to the exhibits at the Augur exhibition:—

(*a*) SIEMENS & HALSKE equipped a window with flame arcs yielding a yellow light. Flame-arcs were also utilized by the CARBONE-LICHT-GESELLSCHAFT. The mechanism of these lamps resembles that of the high-voltage flame arcs, to which reference will be made later. KÖRTING & MATHIESEN, whose well-known *Excello* lamps utilize the Bremer patents, also exhibited, but not in the display of shop-window lighting. These lamps are made for direct currents of 6, 8, 10, 12 amperes, and 44, 45, 46, and 47 volts respectively. WEINERT of Berlin likewise exhibited intense flame arcs intended for currents of 6 to 15 amperes, and 45 to 47 volts.

A singular form of lamp was exhibited by the BECK BOGENLAMPEN GESEL. of Frankfürt, which was supposed to solve the problem of the arc-lamp mechanism, by dispensing with it entirely. A mechanism of this kind is usually regarded as necessary in order to correct for the slow burning away of the electrodes and the variations of pressure of the circuit; in my opinion a lamp without some such arrangement would be an impossibility.

The general nature of this lamp, however, will be gathered from Fig. 11. A series coil is caused to attract an iron core, and so, by a special lever arrangement, to actuate two inclined carbons. It can be seen at once, therefore, that this cannot really be described as a lamp without mechanism, though it is true that the mechanism is of a simple nature. It might, perhaps, be described as a "lamp without clockwork."

The length of the arc being maintained rigidly constant no compensation can be made for small variations in current due to want of homogeneity of the carbons, and therefore fluctuations in the light given by the lamp would occur, were it not for the balancing metallic resistance in series with the arc, acting on similar lines to that utilized in the Nernst lamp. A diminution in the resistance of the arc tends to increase the current, but this is checked by a corresponding increase in the compensating resistance.

The lamp is intended for series-burning, the length of arc being rigidly regulated so that the P.D. maintained constant. The lamps are made for currents of 8 to 12 amperes, and pressures of 42 to 47 volts. According to the results of Wedding they run at a consumption of 0·163 watts per H.K. Special combination lamps are built for very high intensities up to as much as, perhaps, 30,000 H.K., utilizing four distinct lamps within a single case.

(*b*) The next group of arc-lamps exhibited which claim attention are the *High-Voltage Open-type* lamps. The problem of producing a satisfactory high-voltage arc has often been attempted, but until recently without any satisfactory solution. The question has been again taken up, however, and this time with better result, in the development of the *Excello* arc. These lamps are specially well adapted to show-window illumination because of their strong intensity in a downward direction, which allows the lamps to be placed,

out of sight at the top of the window behind a screen of diffusing glass. This plan was adopted as early as 1877 in the Grands Magasins de Louvre in Paris. The colour of the light, however, was regarded as a disadvantage, and in 1905 KÖRTING & MATHIESEN introduced their "Ideal Form of Show-

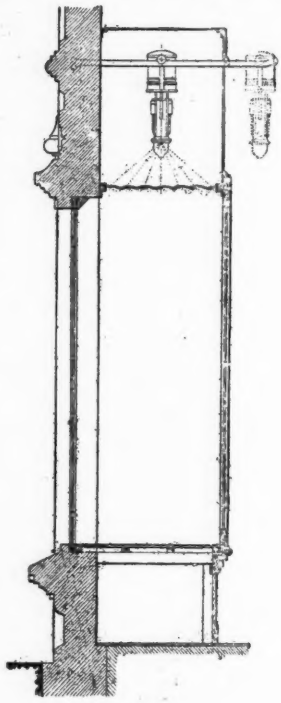


FIG. 12.

Window Illumination," in which lamps of the same character were utilized, but carbons yielding as far as possible a *pure white light* were employed. A special modification of the deflecting magnet was also introduced which blew out the arc into a globular form, instead of the crescent-shaped form previously employed, the new lamp being termed the *Excello-Globe-Flame* arc-lamp. The same device had been previously adopted by F. L. CARBONE in 1901 (German Patents, 141,675, 147,764, 148,878, 150,736).

The exhibit of KÖRTING & MATHIESEN, which is shown diagrammatically in Fig. 12 and 13, was an excellent example of this method of shop-window lighting. The window was filled with metal-ware. In Fig. 12 the arcs are shown suspended above the diffusing sheets of glass in the manner previously explained. It will be seen that they are completely screened from the eyes of the customer, throw the light where it is wanted, on the goods themselves, and produce a very satisfactory diffusion of the light. The lamps are suspended on rollers of the kind shown in Fig. 13, and can easily be withdrawn for recarboning, &c., without interfering with the contents of the window in any way. A lamp removed for this purpose is shown dotted in Fig. 12.

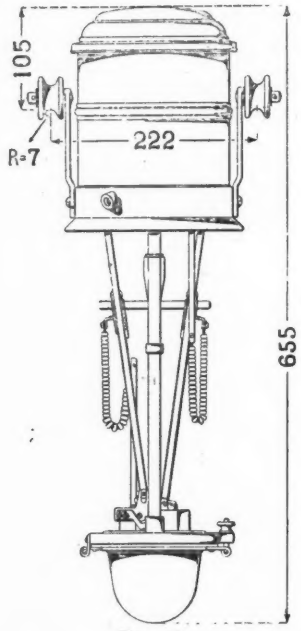


FIG. 13.

(*c*) Reference has already been made to the class of "economy-lamps": the *Triumph* lamps of KÖRTING & MATHIESEN, the *Helix* lamps of the CARBONE - LICHT - GESELLSCHAFT, and the lamps exhibited by the Regina-Bogenlampen Fabrik of Cöln-Sulz, are examples of such lamps. They present no very special features, employing vertical co-linear carbons, mechanisms

of the ordinary variety, and running at about 3 to 5 amperes and 84 volts.

(*d*) Finally, we may mention the miniature arc-lamps, which were represented by the *Miniatur* of KÖRTING & MATHIESEN, and the *Reginula* of the REGINA BOGENLAMPEN FABRIK.

Some particulars of the cost of the various exhibits are given in Table III., exactly as was done in the case of the earlier sections, I. and II.

The CARBONE-LICHT-GESELLSCHAFT and the usual paraphernalia, boots and shoes, silken goods, &c.

When designing to illuminate shop windows with arc-lamps we must, of course, consider whether the variety of light yielded by them will be agreeable or the reverse. The yellow character of the light yielded by many flame lamps, for example, is generally considered to be unsatisfactory when any very delicate shades of colour are to be illuminated. In such a

TABLE III.

		Regina Bogen Lamp Fabrik. 4 "Heller" Lamps.	Regina Bogen Lamp Fabrik. 4 "Reginula."	Siemens & Halske. Flame Arc Lamps (yellow).	Carbone Licht Ges. High voltage open arc lamps (2).	Carbone Licht Ges. 2 "Radiante."	Carbone Licht Ges. Flame arc lamp (yellow).
I. Initial costs of Installation.	(*a*) Of one lamp	60	46	88	80[2]	47[2]	82[2]
	(b_1) Of the whole installation, inside illumination...	120	200	188[1]	160[3]	94·0[3]	164[3]
	(b_2) Ditto, outside illumination... ...	160					
II. Cost of energy for one hour.	(*a*) For one lamp	0·22	0·11	0·176	0·35	0·22	0·22
	(b_1) For the whole, inside illumination	0·44	0·44	0·352	0·70	4	0·44
	(b_2) Ditto, outside illumination... ...	0·44					
III. Renewal expenses for 1,000 burning-hours.	(a_1) Glass ware and accessories ...	2·00	2·00	28·0	10·0	1·2	23 0
	(a_2) Electrodes	2·50	2·40				
	(b_1) Installation glass ware, &c. ...	8·00	8·00	—	20·0	2·4	46·0
	(b_2) Electrodes	10·00	9·00	—			

[1] Inclusive of resistance.
[2] Intensities of respective lamps, 1,600, 800, and 3,000 H.K.
[3] Total intensities of respective entire installations, 3,200, 1,600, and 6,000 H.K. respectively.
All costs are reckoned in marks.

exhibited two windows. The first of these could be illuminated by either of two systems or by both conjointly. In this case high-voltage open lamps were erected on the ceiling inside the shop, and two *Radiante* lamps without. In the second window flame arcs were employed.

In all six windows were illuminated by means of arc-lamps. Among the classes of goods illuminated mention may be made of a dinner-table completely equipped with cloth, dishes, case a high-voltage open lamp specially designed to this end should be used.

On the other hand, when we are dealing with very striking and pronounced colours the colour of the flame-arc is less objectionable—may, indeed, even be of advantage in cases in which it is desired to bring out certain colours. The majority of enclosed arc-lamps and miniature lamps give light of a more or less blue tinge, and therefore tend to accentuate this shade of colour. One would, there-

fore, also exclude the use of these lamps in cases where very delicate shades are to be distinguished. They may, however, be used very successfully for the illumination of a window containing only white goods.

A new and interesting colour-device was shown by the A.E.G., in which the colour of the light coming from above was changed in some manner invisible to the customer on the pavement, the window being flooded with light of any character at will. I understand that the effect was not, in this case, produced by the use of coloured glass, but by reflection from coloured surfaces, driven by an electromotor.

gas lights have also placed gas in a very much more favourable position as regards general convenience in comparison to electricity than was formerly the case, and at a very slightly increased cost.

In short we are in a position to produce any special effect that may be desired by either illuminant. The difference in colour between modern mantles and metallic filament lamps is also not great enough to give either illuminant any very decided advantage. On the whole, therefore, it appears that when the choice is limited to these illuminants, the matter will be settled mainly by the actual

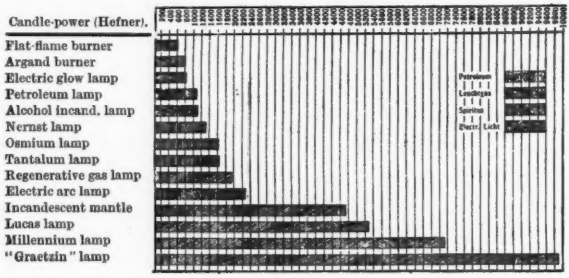


FIG. 14.

CONCLUSION.

In the case of both electric and gas incandescent lamps, it may be said that there is ample choice for the purpose of shop-lighting, and that both systems of lighting present sufficiently diverse types of lamps to meet any requirements that are likely to occur. In both cases fixtures and lamps are available which can be burnt hanging from the ceiling, mounted on the walls, or as concealed lamps in the foreground of the shop, and in both cases lights giving the desired range of intensity and form of polar curve of distribution of light.

The improvements in methods of automatic lighting up and extinguishing

costs in the two cases. Naturally it is impossible to lay down any very definite rule as regards this point; the relative economy of the two systems depending on the costs of gas, and electric energy, the P.D. of supply, and other local circumstances.

In the case of arc-lamps the same general observations apply, except that the cost of light-production is, in general, considerably lower, and that the question of colour becomes of greater importance.

In Fig. 14 is shown the relative economy of a variety of illuminants, as stated by the Viel-Licht-Gesellschaft, on the basis of the intensity of light available, for one hour at a cost of 1 mark.

Some Examples of Shop Lighting by Gas.

RECENT numbers of the *Journal für Gasbeleuchtung*, &c., contained some description of the gas-lighting exhibits of Messrs. Ehrich & Graetz and the Pharos Licht-Gesellschaft at the Berlin Augur Exhibition, and we are indebted to these two firms for the illustrations accompanying our reference to this section of the exhibition.

We have already laid stress upon the desirability, in lighting shop windows, of separating the purely advertising functions of the sources of light placed outside the shops and the qualities which enable them to effectively illuminate the goods in the window. For this latter purpose it is essential that the sources themselves should be either concealed from view or, as far as possible, placed in such positions as not to interfere with the vision of the customer on the pavement. Other critics besides Dr. Stockhausen seem to have been struck by the fact that many of the exhibitors in the Augur display indulged in needless extravagance in the amount of light used, and, moreover, utilized this light in such a way as to dazzle the eyes of the customer. The method adopted by Messrs. Ehrich & Graetz is intended to attain the desired results by concealing the lights actually intended to illuminate the goods behind some ornamental and semi-transparent device such as that shown in Fig. 1. In this connexion they give the following table illustrating the relative costs of energy of gas of various types of lighting exhibited.

In a recent article dealing with the Pharos-Licht exhibit, however, it is explained that the figure given for the Pharos system in the above table ought by rights to be divided by two, for it is calcuated on the assumption that two lights are employed to illuminate the window, whereas one single amp suffices.

In the article to which we are now referring (*J. f. G.*, April 11th, 1908) the main points to be attended to in an effectively illuminated shop window are stated as follows :—

1. The goods themselves must not be injured by the sources of light by means of which they are illuminated (*e.g.*, their colour must not be caused to fade or the material injured by noxious fumes given off by the illuminant, &c.).

2. The goods must be so lighted that every object must appear to the observer completely illuminated by light striking it from the front.

3. The method of lighting must not give rise to much heat within the window, otherwise a deposit of moisture will be formed on the panes in winter, which will prevent the contents of the window from being clearly seen.

Although these conditions were not actually specified by the authorities at the Augur exhibition, the author claims that they are nevertheless essential when very fine and easily damaged goods are to be illuminated. Moreover, in many such cases it is even desirable to enclose the precious

TABLE I.

Name of Lamp.	System of Lighting.	Cost of Gas or Electricity per Hour.
Graetzin Light	Inverted incandescent mantles	15 pfennigs.
„	Inverted incandescent mantles	17 „
	Electric glow lamps I.	24 „
Pharos Light	High-pressure incand. gas lamps	25 „
Tantalum Lamp	Electric metallic fil. glow lamp	25-6 „
Lucas Light	High-pressure incand. gas lamps	26 „
Eros	Inverted incandescent mantles	29 „
Carbone	Electric arc lamps	44 „
Reginula	Electric arc lamps	44 „
	Electric glow lamps	48 „
Nernst Lamp	Electric glow lamps	70-4 „
Regina	Electric arc lamps	88 „

goods within an air-tight and dust-tight enclosure.

In view of these considerations the Pharos Co. adopt either an external system of lighting by a single lamp, or interior lighting by two lamps. But in either case, as will be seen from the alternative methods shown in Fig. 2, precautions are taken to secure that actual productions of combustion, &c., cannot injure the goods, [by keeping the actual sources of light outside the enclosure containing them. The first method of illuminating the shop window from the front by a single 2,000 H.K. lamp, costing about 12 pf.

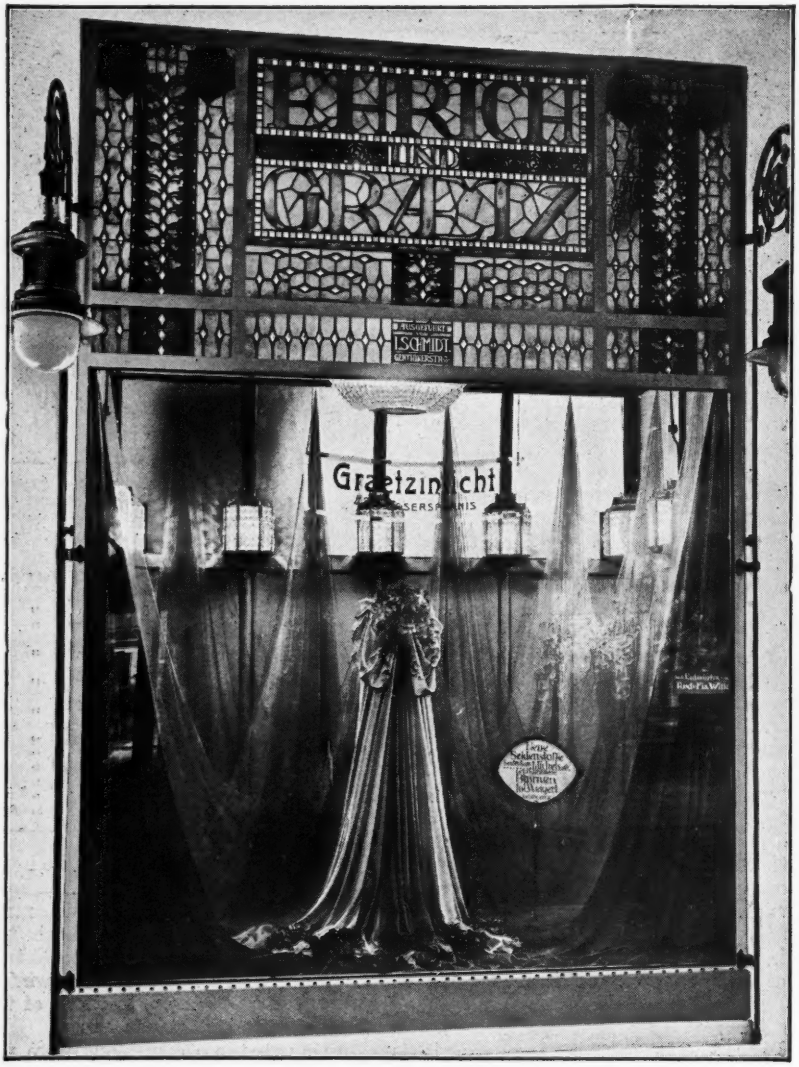


FIG. 1.

per hour is, however, almost invariably adopted. Other examples of shops so lighted are shown in Fig. 3.

In this way, it is claimed, the required conditions are complied with. The Pharos Licht Co. also claim that the method of illuminating goods from the front is advantageous, because it avoids the possibility of the goods themselves throwing shadows, and so interfering with the appearance of the window. In order to secure that lights placed outside the shop in this way should not dazzle the eyes it is customary to provide them with globes which are partially obscured on the side facing the street, but clear on the side facing the window.

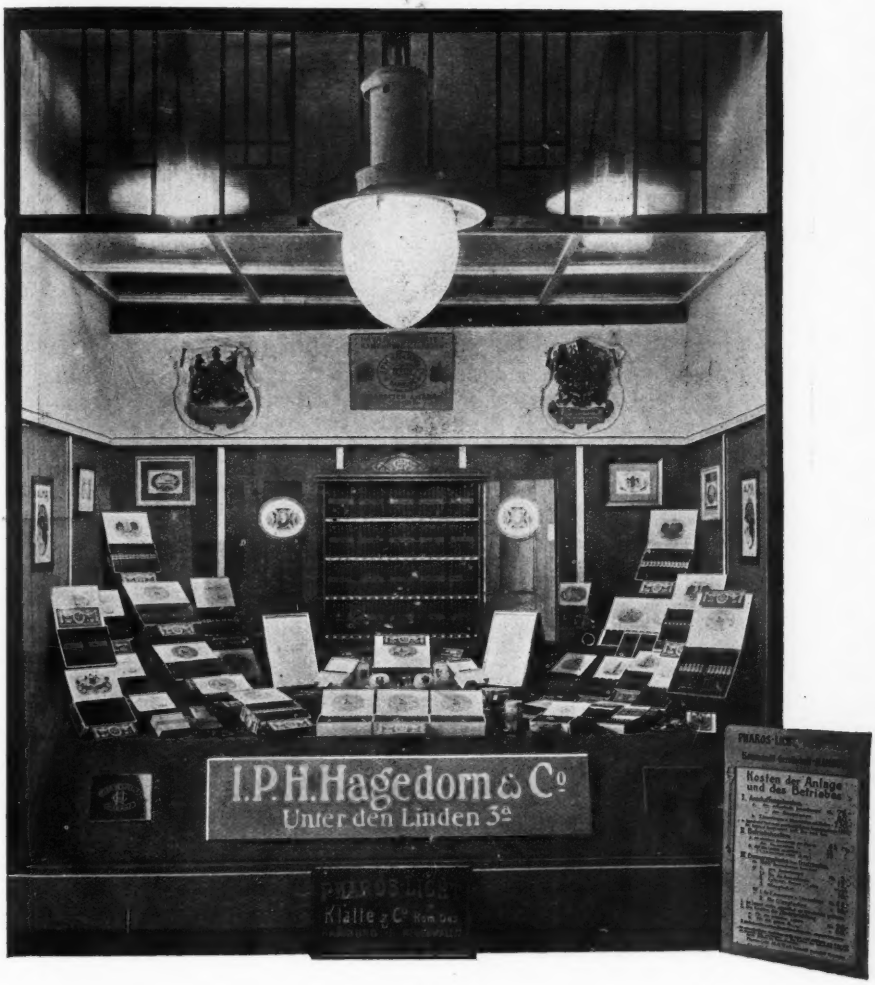


Fig. 2.



FIG. 3.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

Why Light is Believed to be a Vibration, and what it is that Vibrates.

(Two Lectures delivered by PROF. TROUTON, M.A. D.Sc. F.R.S., at the Royal Institution, May 12th and 19th.)

IN these two lectures Prof. Trouton traced the gradual development in the theory of light. It was, he said, peculiar that this development originally started on what are now considered to be correct lines, and yet afterwards wandered off, for a century, into what now seem impossible directions.

Strange to say, it was the overwhelming authority of Newton that was responsible for these incorrect conceptions. Newton adopted the view that light was due to luminous particles being continually projected from the light-giving surface. Previously Huyghens had put forward the wave-theory of light, and we to-day rely on a theory of this description. But the waves suggested by Hughens differed materially from those we now recognize. He believed that these waves vibrated longitudinally, in the actual direction of transmission. Nowadays it is believed that light-waves act *transversely, i.e.*, at right angles to the direction of propagation.

Assuming, therefore, that light vibrates in this way, what differences must be looked for in ordinary waves of light? They may, firstly, succeed each other at longer or shorter intervals, and secondly, they may vary in amplitude. The first of these qualities settles the "pitch" or colour of the light, the second determines its intensity. Two kinds of light would therefore appear to be identical, if they possess exactly the same colour and exactly the same brightness.

There is, nevertheless, yet another quality of light-waves which must be taken into account. This new property is *direction of vibration*. We have stated that light consists of vibrations in a direction at right angles to that in which they are travelling, but there are many such directions. We have not as yet mentioned whether the vibrations all take place parallel to each other in a certain plane, or whether they may take any direction provided only that they are perpendicular to the ray. Both varieties of vibration may exist. Meantime we may note that on this fact depend certain properties of the ray of light, for which Newton, reasoning from the idea of longitudinal waves, was quite unable to account, and therefore turned to his emission theory.

Huyghens applied his theory to explain the double-refracting properties of many crystals, but could not explain why the rays should travel faster in one case than the other. The explanation of this effect was only realized when the idea of transverse waves was introduced.

An important link in the chain of evidence to prove that light consists of transverse vibrations, demonstrated by Young, lies in the fact that waves can be timed so to arrive at a given surface as to reinforce their mutual action in some regions, and to neutralize it in others. Thus, when light of a given wave-length is reflected from a film of oil spread over water, there are certain places where the light appears to be reflected, and others where it does not. The location of these regions depends upon the thickness of the layer of oil. If the thickness at any point happens to be just enough to enable the light-waves reflected from its upper and lower surfaces to arrive in time, and to reinforce each other, we get light. If, on the other hand, they arrive in exact opposition, the crest of the one wave over the hollow of the other and vice versa, we get darkness. And the calculated thickness

of the film resulting in these patches of light and darkness can be verified by exact measurement.

Another class of phenomena which afford no little insight into the mechanism of light-propagation is that of light-shadows. One of Newton's arguments against the wave-theory rested on the assumption that if light were of this nature, there ought to be no shadows; and that light ought to be able to turn corners, just as occurs in the case of sound. Yet we know from common observation that light travels in apparently straight lines, and does not seem to be able to turn corners to any appreciable extent.

Actually, however, if the action of light passing over a very sharp edge is studied scientifically, we find that there *is* a small amount of bending possible, but only to a degree commensurable with the extreme smallness of the wave-length of light. This ability of light to turn corners is so completely explicable on the basis of the wave-theory as to afford another excellent means of measuring the wave-length of light.

In a second lecture Prof. Trouton returned to the discussion of the exact nature of the transverse vibrations of which light-waves consist. Such vibrations may be confined to one plane, and we can prepare crystals, which allow such a beam of "plane-polarized" light to pass through in one position, but completely obstructs its passages in a position at right angles. The specially constructed "Nicol-prism" serves this purpose.

Such a beam of light has also the peculiar property that it fails to be reflected when striking a reflecting surface at a certain angle. A number of slides were shown by the lecturer illustrating the behaviour of polarized light passing through selenite and other crystalline media. Glass, when subjected to strain by being squeezed, shows similar effects.

All these phenomena can be so completely explained on the basis of the wave-theory as to justify our belief in the transverse vibration of light. The question remains what exactly is it that vibrates?

It has been conjectured that light-vibrations are transmitted by the aid of an absolutely all-pervading substance known as the "ether." Much information has been obtained as to the properties of such an "ether" by the study of electrical phenomena, which being, like light, transmissible through space, demand the assumption of the existence of some such peculiar transmitting medium.

At one time it was supposed that there were five distinct ethers, but Maxwell was able to show that it was only needful to suppose the existence of one single ether, equally capable of transmitting light and electricity. Subsequently the practical work of Hertz fully confirmed Maxwell's suggestions. Hertz was able to produce electric waves, of the same nature as those used to-day in wireless telegraphy, and to show that these waves could be reflected and refracted, polarized, &c., just as in the case of light. They were, in fact, merely light-waves of very great wave-length.

The analogy between electric- and light-waves also enables us to settle one point as regards the vibration of the latter, on which some doubt was previously felt to exist.

When a beam of plane-polarized light refuses to be reflected, is this because the vibrations are parallel to the reflecting surface, or because they are perpendicular to it?

Now in the case of electric waves we have no difficulty in deciding the direction of vibration from the line of the discharging apparatus radiating waves. And, in the case of such waves, we find that the direction of vibration must be parallel to the surface in order to secure the best reflection, and conversely perpendicular to the surface in order that the light reflected may be a minimum.

Finally, therefore, we arrive at the conclusion that light is a vibration propagated in the same medium as that in which electric phenomena arise. Electricity, it is becoming increasingly evident, plays a very important part in natural phenomena. It may be that matter, and even the ether itself, may ultimately prove to be but a manifestation of it.

On the Temperature of Incandescence of Glow-Lamps.

By K. Sartori.

(From *Elektrotechnik und Maschinenbau*, March 22nd, 1908.)

Although we have succeeded in producing satisfactory metallic filament glow-lamps running at a much higher efficiency than the carbon filament lamps used to do, yet the exact explanation of this improvement is far from clear.

In considering this subject we must first understand the nature of the physiological perception of light on which our impressions of brightness are based.

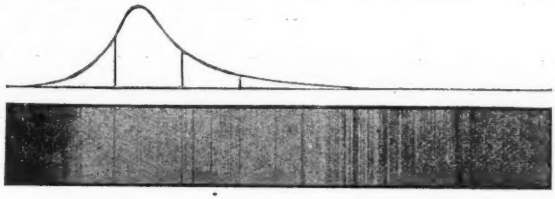


Fig. 1.

The human eye is most sensitive to the central region of the spectrum, in the neighbourhood of the green-yellow, corresponding to the lines D and E. This appears to be a consequence of the fact that the eye has developed in such a way as to use daylight to the best advantage. At the enormous temperature of the sun—estimated at about 6000 degrees—the maximum amount of energy is situated in a region of the spectrum very closely approaching that for which the maximum sensitiveness of the eye occurs. The high efficiency of many flame-lamps may be ascribed to the fact that a line-spectrum is super-imposed over the main radiation, so that several very bright lines are added in this favourable region of the spectrum. This method of improving the efficiency of radiation of a source is, however, excluded in the case of glow-lamps, for incandescent solids which do not yield line-spectra.

In Fig. 1 is exhibited the distribution of brightness in the solar spectrum as determined by Frauenhofer. In this curve the abscissæ represent the wave-lengths of the spectrum and the ordinates the intensity. The maximum sensitiveness occurs, as previously stated, in the yellow-green.

Fig. 2 represents the energy-curve of the prismatic solar spectrum, as determined by Langley. In this case the values of the intensity of the energy of radiation measured by means of a bolometer, are taken as ordinates.

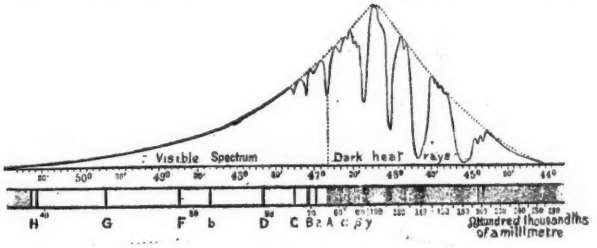


Fig. 2.

The corresponding curve for a grating-spectrum is shown in Fig. 3. Although referring to the same source of light as Fig. 2, namely the sun, it will be seen that the shape of this curve is very different.

This arises from the fact that a prism

does not refract all rays according to the same law, but disperses those rays more effectually, which lie towards the blue-violet end of the spectrum. In consequence of this property of the prism, which is termed anomalous dispersion, the less easily refracted rays are crowded together, and the energy-maximum does not occur at the correct point. The grating, however, is quite free from this peculiarity, and hence the different nature of the curves in the two cases.

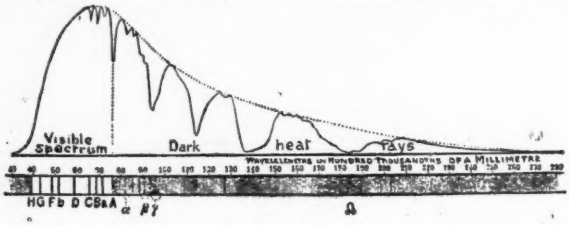


FIG. 3.

In the case of the sun, then, the energy-maximum and the position of maximum sensitiveness of the eye coincide. But the temperature of ordinary sources of light is far too low for this to occur. By increasing the temperature we bring the position of the energy-maximum nearer to the visible range of radiation, but even at such a temperature as that of molten platinum the maximum still falls far without the visible range. How great is the difference in the behaviour of this radiation and that of the sun is shown in Fig. 4. Fig. 4 represents the distribution of energy in the spectrum of the sun and the Violle standard respectively, the visible range of radiation being left blank, and the other invisible portion of the spectrum shaded.

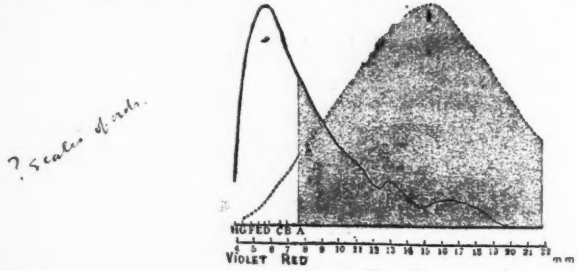


FIG. 4.

According to the law of Kirchoff, a heated body is in a position to radiate just those rays which it can also absorb. For this reason a bunsen-flame appears non-luminous. It is transparent to visible rays, and therefore it cannot radiate them. If, however, we place a little common salt in the flame it becomes coloured with the characteristic yellow tinge of the sodium flame. In virtue of this fact the flame is now opaque to rays of this colour. If, therefore, we place a sodium flame between the slit of a spectroscope and a brightly incandescent solid we see a dark band in the neighbourhood of the sodium D line, caused by the obstruction of these particular rays.

A "black" body is a body which is able to absord all radiation impinging upon it, and is, therefore, also able to give out all these varieties of radiation. Such a body must tend to be uneconomical from the point of view of light-production, because it will give out many varieties of radiation which are invisible.

On the other hand, bodies which radiate "selectively," *i.e.*, show a marked preference for giving out certain kinds of radiation, may be more efficient light-producers than black bodies, if they happen to prefer to radiate energy lying within the visible spectrum.

In general, a brightly polished metal will, at a given temperature, glow more brightly than one with a dull black surface. (This was illustrated by an experiment with black and brightly polished platinum. When the strip was brought to incandescence by means of an electric current it became evident that

the brightly polished portion glowed the brighter.) Herr Sartori then proceeds to describe an experiment of Melloni's, in which it was shown that a brightly polished metal surface had to be heated to a temperature of 800 degrees in order that it might give out the same total radiation as that yielded by a corresponding blackened surface at a temperature of only 100 degrees. Magnus has also found that the selective radiation of an object is affected by the quality of the surface.

One very important law of radiation is that of Wien, which is essentially as follows :—

$$\lambda_m \cdot T = \text{Constant.}$$

Where λ_m is the wave-length corresponding to the maximum of the energy-curve, and T the absolute temperature. The constant varies but little in the case of different substances. Lummer has found the values 2940 and 2630 for a black body and bright platinum respectively. According to Wien's relation the temperature of the sun should be—

$$T = \frac{3000}{0{\cdot}5} = 6000 \text{ degrees (abs.)}$$

By the aid of this law it is possible to form a fairly correct idea of the temperature of a body from the nature of its radiation, but for this purpose it is essential, for the reason mentioned above, that a grating-spectrum should be utilized.

The author has undertaken some experiments with the object of comparing the temperature of incandescence of carbon and metallic filament lamps. For these experiments he at first used a Zeiss grating having 14,400 lines to the inch. The dispersion of the grating for the visible portion of the spectrum was about 13 degrees, and sufficed both to clearly separate the two sodium D lines, and to enable other fine lines to be perceived between them. In spite of the excellent optical properties of the grating, however, it proved to be unsatisfactory for the purpose in view, because the energy which could be focussed upon the bolometer was too small to enable reliable readings to be obtained. Eventually, therefore, the author decided to return to the less satisfactory prism apparatus. A Cook spectrometer was utilized, the flint glass prism employed in this apparatus being, however, exchanged for one of crown glass, giving less dispersion but greater energy. In place of the eyepiece of the telescope a bolometer was fitted, and by this means it was at length found possible to obtain reliable results ; the apparatus is shown in Fig. 5.

The energy curves of a 3·5 watt per H.K carbon filament lamp, and a metallic filament one taking 1 watt per H.K., were then studied, and it was found that the maximum was distinctly nearer to the violet end of the spectrum in the case of the carbon filament lamp. Applying the law of Wien, therefore, it would seem that the temperature of incandescence of the carbon filament lamp was the higher of the two.

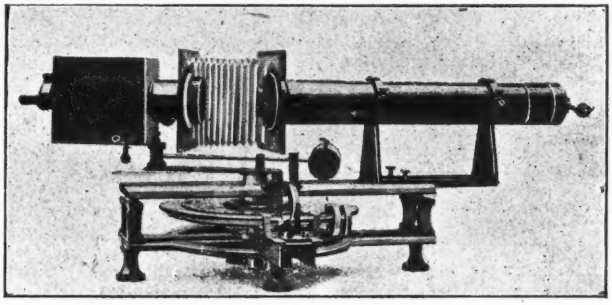


FIG. 5.

Nevertheless, one would certainly exercise caution in concluding that this is the case, because there are many other facts which suggest that the great efficiency of these lamps is to be ascribed to their high temperature. On the other hand, the researches of Melloni make it evident how greatly the radiation of metallic surfaces differs from that of carbon. Dr. Blau has also maintained that the metallic filament lamp, together with a lower energy-consumption, has a greater radiating surface than a carbon lamp, and that a lower temperature is thereby automatically reached in the former case. Dr. Grau, it is true, has arrived at the result that the temperature of metallic filament lamps is the higher, but it must

be noted that he utilized an optical pyrometer for his measurements. The result he arrived at is, therefore, hardly surprising—is, indeed, the only one possible—because this method of measurement assumes that a higher intensity of radiation of any specified portion of the spectrum is a criterion of higher temperature; this, of course, is the acutal question, the solution of which is being attempted.

In the discussion of the paper Prof. Grau inquired whether Herr Sartori was able to estimate the supposed difference of temperature between the two lamps. Herr Sartori replied that he was not in a position to say exactly to how a great difference of temperature the actual angular difference of thirty minutes on the spectrometer corresponded, because, for the reason previously mentioned, the prism apparatus utilized by him was not adapted to the measurement of absolute temperature.

Prof. Grau remarked further that Lummer's researches had placed the temperature of the carbon filament lamp near 2100 degrees. On the other hand, the bolometric measurements of Kurlbaum and Pringsheim suggested a value nearer 1600 to 1800, and therefore it seemed that the law of Wien could not be rigidly applied. As regards the question whether the temperature of the metallic filament lamps was really lower than that of carbon filament ones, the extremely interesting results of Auer, with a platinum-osmium composition, suggested a contrary result, for in this case a temperature of 2000 was reached, which is higher than the temperature ascribed to the carbon lamp by the work of Kurlbaum and Pringsheim. Blau and Lombardi have both been led to suggest that the temperature of the osmium lamp is in the neighbourhood of 1460 degrees. There are, however, researches of Burgess, and also those of Morris and Ellis, who estimated the temperature by noting the expansion of the hoop of a filament, which are opposed to this view.

Herr Sartori replied that no actual method of measuring temperature exists. We can only base our impressions upon phenomena which occur at various temperatures, and hence our so-called methods of measuring temperature are really based upon convention. And even the study of the expansion of a heated body as a means of estimating its temperature rests upon a purely conventional basis

A Correction.

Dr. F. Blau writes to us to explain that he does not hold the opinion, attributed to him in the journal from which this paper is abstracted, that the osmium filament radiates at a temperature of 1460° C. On the contrary, he believes that this cannot be the case, and that the temperature in question is much too low.

We notice that a similar letter on this subject from Dr. Blau appears in *Elektrotechnik und Maschinenbau*, in which he states that the responsibility for this suggestion rests not with him, but only with Dr. Lombardi.

Dr. Sartori has also written to explain that he did not attribute the opinion referred to to Dr. Blau, nor does he himself believe that the temperature of incandescence of an osmium filament can be as low as 1450°.

Prof. Grau, too, writes that in quoting Dr. Blau he did not connect him with the work of Lombardi yielding such low values.

CORRESPONDENCE.

Co-Operation between those representing Gas and Electric Lighting.

To the Editor of 'The Illuminating Engineer.'

SIR,—The publication of the results of some of our work on the City lighting makes me wonder whether it will be the occasion of more antagonism between those who are interested in gas and those who are interested in electricity. Personally I am a greater advocate of going to bed when it is dark than of either gas or electric light, and as I desire above all to promote unity among men rather than discord, I will ask you to allow me to say a word to both parties in this discussion. When one observes the terrible waste of human life and material that is taking place, a waste that does not arise so much from the want of technical knowledge as from its neglect; when one looks upon the terrible farce that is proceeding once more before a Committee of Parliament, and when one carefully examines the cause of these dreadful things, one is led irresistibly to the conclusion that they arise from want of unity among men. Instead of adding one to one and making two, we are everlastingly subtracting one from one and making worse than nothing. This madness has proceeded so far that recovery is probably a difficult matter—we are like people bound by some magic spell. Yet delivery from this spell must come sooner or later, and when trade is bad is the best time to stop and think, for when trade is good few of us will ever think of what we are really doing.

Now, both gas and electric light people are public servants fulfilling the same task in different ways. It is quite easily ascertainable as a matter of fact, and not as an opinion, that electricity can be under most circumstances cheaper for lighting and gas cheaper for heating; but even supposing this were not so, and that the fact were quite different, why should not both unite to do that which is best, and find some reasonable basis of agreement by which both should get a fair return for the services they render?

Of course, the suggestion of a combination between the gas and electric light people is enough to make the hair of the average trader stand on end, and justly so, if a superficial view of the case is taken. As buyers we all know the apparent advantages of price cutting; but try and trace out the whole system of trade competition, and we shall find that we gain 1*d.* in one pocket and lose 2*d.* out of the other, and that the whole thing is madness, which is bringing us to destruction. If we are going to admit that one man will not properly serve another man unless a third man is waiting to eat him up if he does not, then disaster is already complete. But I will not believe it, and I say the time is now ripe for men to take a more serious and simple view of what is proceeding, and endeavour to stop the madness that is now destroying us.

The unity that I ask for among all parties interested in the electric supply of London I would like to see extended to those interested in gas, and as a practical man having the good of all the people of London at heart I do not believe that there would be a great deal of difficulty in preparing a scheme which would satisfy Parliament if we all tried to be reasonable.

I am, &c.,

A. A. VOYSEY.

Dorking, June 6th.

P.S.—It may be thought that there is an argument against what I have urged in the fact that the gas mantle, the metal filament lamp, and the flame arc-lamp have possibly been developed as the result of competition between gas and electricity, but it is no argu-

ment against me. Do we not all know that the great discoveries which have advanced the consciousness of man have been made for the love of truth and not for the love of self? Is not my own experience like that of all men, that the less I think of the size of my salary the better my work becomes? If we were not madly trying to eat each other up we might now be considering a scheme for the partial conversion of gas works to join with the electric light works in endeavouring to give London the cheapest possible light with a reasonable profit, instead of wasting our money over propositions for further waste and chaos.

The Temperature of Incandescence of Metallic Filament Lamps.

Naples, June 21, 1908.

DEAR MR. GASTER,—In reply to your kind inquiry, I have much pleasure in sending you a copy of the paper delivered before our Associazione Elettrotecnica in 1903, which was subsequently abstracted in the *E.T.Z.*

My results, according to which the osmium lamp appeared to have a lower temperature of incandescence than that of the carbon filament lamps, have been contested in several quarters, mainly on the ground that they were derived from the Weber theory of glow-lamp filaments, the principles of which are not in accordance with the more modern theories. In this connexion I may remark that the metallic filaments of the modern glow lamps are not truly black bodies, and that measurements which are carried out with the ordinary pyrometers are more or less influenced by the errors and uncertainties involved in the calibration of such instruments.

I therefore proposed to undertake a further research on the metallic filaments of the glow-lamps of to-day, and to verify the consequences of the Weber theory directly, but unfortunately I have lacked the time as yet. In the event of my being in a position to collect some new material bearing on these interesting questions, I should be very glad to send your journal a short contribution on the subject.

I am, yours sincerely,

L. LOMBARDI,

Professor at the Technische Hochschule, Naples.

Neapel, 21 Juni, 1908.

LIEBER HERR GASTER! — Bezug nehmend auf Ihre freundliche Anfrage, beehre ich mich Ihnen ein Exemplar eines Vortrages zu senden, welchen ich vor unserer Associazione Elettrotecnica im Jahre 1903 gehalten, und in der *E.T.Z.* abzugsweise erscheinen liess.

Meine Resultate, welche für die Osmiumlampe eine niedrigere Temparatur wie diejenige der Kohlenfaden ergaben, sind von verschiedenen Seiten bestritten worden, hauptsächlich aus dem Grunde, dass dieselben aus der Weber'schen Theorie der Glühfaden stammen, deren Grundlagen nicht in Ubereinstimmung mit der modernen Theorie der Glühkorper steht. Darüber möchte ich nur bemerken, dass die Metallfaden der modernen Glühlampen keine schwarzen Körper sind und die Messungen, welche mit gewöhnlichen Pyrometern aufgestellt wurden mehr oder weniger mit den Fehlern und der Unsicherheit der Kalibrierung der Instrumente behaftet sind.

Ich hatte daher im Sinne, eine weitere Untersuchung der Metallfaden der modernen Glühlampen zu unternehmen und die Folgerungen der Weber'schen Theorie direkt zu prüfen. Dafür fehlte mir aber leider bis jetzt die Zeit. Im Falle, dass ich nächstens im Stande ware, neues Material über diese interessante Frage zu sammeln, wäre ich gerne bereit eine kurze Mitteilung darüber an Ihre Zeitschrift zu senden. Hochachtungsvoll:

L. LOMBARDI,

Prof. an der Techn. Hochschule Neapel.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

ONE of the most important recent papers on matters connected with illumination is that of E. L. Nichols (*T.I.E.S.*, May), who contrasts the qualities of various types of artificial illuminants with those of daylight. Both the nature and intensity of daylight illumination differ very considerably under different conditions and at different periods of the same day. This is illustrated by the numerous curves given by Dr. Nichols, who, however, accepts diffused daylight as the normal stimulus to which the eye is exposed. Sunlight is almost invariably less blue than diffused daylight. Therefore we may take it as a principle that artificial illuminants ought to yield light as nearly approaching diffused daylight as possible. The numerous curves given in this paper show how rarely this is the case. As a general rule incandescent carbon and metals yield the nearest approach to it, incandescent oxides coming next, while incandescent vapours, such as are utilized in the mercury arc, deviate very widely indeed—so widely as to be only with difficulty comparable.

J. Sorber (*T.I.E.S.*, May) discusses the bearing of such natural phenomena as the position of the sun with respect to the earth on human development. He argues that the fact that the sun is overhead, and not on the horizon, during the greater part of the day has induced the human species to gradually assume an upright attitude, and suggests that the natural imitation of nature's method of illumination would entail the production of a source of very great candle-power suspended at a great height above the earth, so that its rays reached us from above just as the light from the sun does.

N. M. Black (*Optical Journal*, U.S.A., June 11th) raises the question, What is the best variety of artificial light to be used by opticians in illuminated test-screens ? and also whether it is better to illuminate such screens by reflected or transmitted light. The author circulated a number of inquiries on these points, but the replies seemed to have varied among themselves very greatly, and it is difficult to deduce any definite result.

E. W. Weinbeer writes to *The Electrical World* (May 23rd) criticizing a recent article by Wohlauer, on the ground that the polar-curve of distribution of light adopted by the latter could not actually be obtained in practice. A. A. Wohlauer, however, replies that such a curve can be obtained by the use of suitable reflectors (*Elec. World*, May 30th).

An article by J. H. Hart (*Elec. Rev.*, N.Y., May 23rd) discusses the trend of modern types of photometers. He remarks that these instruments may now be divided into two classes, those intended for rapid work and ascertaining the actual illumination on the spot, and those meant for accurate use in the laboratory. He remaks that the former class are proving to have a great field of usefulness, though still imperfect in detail. He also seems to suggest that the limit of utility of the more accurate instruments as a means of research has been reached—a conclusion, one would think, that would be doubted by very many illuminating engineers of the present day.

A. E. Kenelly and S. E. Whiting describe some experiments on the sensitiveness of several types of Lummer-Brodhun and grease-spot photometers, carried out both with lights of the same colour and with slightly heterochromatic sources of light. The former conditions were represented by two carbon filament lamps run at the same efficiency and yielding exactly the same quality of light. The heterochromatic conditions were represented by the comparison of a carbon filament lamp taking 4·5 watts per c.-p. with a tantalum lamp taking 1.25 watts per c.-p.

With lights of the same colour all the observers found the contrast Lummer-Brodhun photometer to be the most sensitive. In the second case they reached very different conclusions ; the mean error also proved to be about 2·6 times that obtained under the homochromatic conditions.

Lautsch (*Elek. Anz.*, June 11th) describes a new form of Rumford photo-

meter, in which the lamps to be compared are kept stationary and the rod, producing the shadow, is moved along a graduated scale. The photometer, however, is only intended for the comparison of sources of light, which do not differ more than about 25 per cent in intensity.

C. Paulus (*Z.f.B.*, June 20th) undertakes a systematic comparison of the three chief methods of obtaining the mean horizontal c.-p. of glow lamps as applied to metallic filaments. These methods include (*a*) the method of point to point individual measurements, (*b*) the angle-mirror method, and (*c*) rotation methods either by rotating the lamp about a vertical axis, or rotating the mirrors about a stationary and screened lamp.

He points out the main drawbacks and advantages of these three, or rather four, systems, when used with lamps having metallic filaments proceeding to calculate the mean deviation of individual results from the determined average in each case. In the instalment of the article that has appeared he finds that the mirror methods are not superior in point of accuracy to the point by point ones. The article is to be continued.

Electric Lighting.

Several recent editorials in the American electrical papers have dealt with the metallic filament lamps industry. *The Electrical World*, for instance (June 6th), refers to two recently delivered papers on the introduction of the tungsten lamps. It is pointed out that the high efficiency of these lamps is so often dwelt upon that the exceedingly high life of the lamps, and the small fall in c.-p., which, under the best conditions, accompanies it, are allowed to pass unnoticed. The writer states that in his experience a life of 1,350 hours at 1·25 watts per c.-p. is not usual. It is also pointed out that the introduction of these lamps is really taking place very gradually. The writer calculates that the present manufacturers in the States would be unable to supply more than about 2½ per cent of the actual demand for incandescent lamps in that country.

J. B. Taylor (*Elec. World*, May 23rd) contributes some additional information on the subject of the initial rise in candle above the normal steady value which he finds to occur in the case of the tungsten lamps, suddenly switched into circuit—the "overshooting" as it is termed. The existence of the effect is demonstrated by a series of photographs.

A recent illustrated article in *l'Electricien* deals with the application of electric light to churches. The writer explains that there is a prejudice against the introduction of modern methods of illumination into churches of historic interest. Yet the greater convenience of good illumination had in some cases led to the claims for the traditional dim methods of lighting being relinquished. Metallic filament lamps are here at less disadvantage owing to the fact that they cannot be made for low candle-powers, because in large interiors, such as churches, big units are essential. The article is illustrated by examples of the application of electric light to ancient church-lighting, but, as far as can be judged from the inspection of these illustrations, the representatives of the æsthetic aspects of the problem might be justified in occasional stubbornness.

J. D. Mackenzie (*Electrical Review*, June 12th and 19th) considers the merits of gas and electric lighting from the standpoint of the small consumer. He remarks that in recent discussions of tariffs it has been assumed that it did not pay supply authorities to lay themselves out for the small consumers. Mr. Mackenzie, however, suggests that such consumers are now worth catering for *en masse*, and proceeds to show how electric light can be proved to be acceptable on the basis of cost—the fundamental consideration in cases of this nature. He admits, however, the great difficulty of the initial cost of installation. In the course of his comparison of the relative cheapness of gas mantles and osram electric lamps he comes to the conclusion that the running costs are about equal when electricity costs 3½*d.* a unit.

A. A. Wohlauer contributes to *The Electrical World* (May 16th) a study of the running cost of various electrical illuminants, ranging from the carbon filament glow-lamp to the new quartz tube mercury vapour lamp. The latter he finds to be the most economical of all, at least on the basis of the figures at present published. A curve is given connecting the running costs with the cost per unit of energy.

A number of technical articles embodying recent patents, &c., bearing on the subject of glow-lamps have appeared of late in the German electrical papers. The most recent instalments of that occurring in the *Zeitschrift für Beleuchtungswesen* (May 30th and June 10th) deal mainly with the existing methods of winding metallic filaments so as to reduce the possibility of breakage to a minimum. Vogel (*Z. f. B.*, May 30th and June 10th) continues his comparison of vapour lamps with lamps utilizing in-

candescent filaments. In the present article he attempts to forecast the lines on which the development of vapour lamps may be expected to proceed.

A report of the Committee of the National Electric Convention has just been issued dealing with the specification of electrically illuminated streets (*Elec. World*, May 30th).

Gas and Acetylene Lighting.

Although the annual meeting of the Institution of Gas Engineers took place during the present month there are no very novel papers on the subject of gas lighting to report.

Several translations of articles or papers recently published in Germany have appeared in the English press, notably that of Drs. Bunte, Mayer, and Teichel, on combustion in incandescent gas lamps, and that of Dr. Lux on the relative merits of compressed air and compressed gas. The latter question again receives ventilation in the *Journal für Gasbeleuchtung* (June 13th).

Anzbock (*J. f. G.*, May 30th) contributes a comparison of the costs of gas and electric lights. He makes the admission that there are certain cases—the lighting of theatres and mines for example—in which electric lighting is essential, but contends that the majority of cases are settled mainly upon the base of cost. It is interesting to find that his figures differ considerably from those given by Mr. Voysey in his report on the City lighting, though the latter were, of course, based on actual measurement in the streets, and not upon the performances of individual lamps. In this case the author finds that the cost of flame arc-lamps works out to about the same as high-pressure gas lamps when electricity costs 3*d.* a unit.

A new variety of illuminating and heating gas has been invented by Dr. Blau (*G. W.*, June 20th). This gas is obtained by distillation at a comparatively low temperature of 600 to 700 degrees, when the heavier and more easily liquified hydrocarbons are obtained. These are then stored in the liquid form in cylinders, each of which is capable of supplying 50 c.-p. for about 480 hours. The gas is said to have a high calorific value, and appears to yield the exceedingly high intensity of nearly 100 H.K. per cubic foot per hour.

Several of the contributions at the International Acetylene Congress were of considerable interest. Chief among these may be mentioned the paper by the President, Mr. Charles Bingham, on the relative merits of petrol-air gas and acetylene. These two illuminants may be said to be rivals, both filling the place of gas and electric lighting in remote districts with success. Mr. Bingham attempted to demonstrate that acetylene is not only cheaper, but more convenient and safer than petrol-air gas, justifying his statements by quotations from the estimates of various firms supplying installations of the latter, and also from the statistics relating to the accidents caused by the various systems of illumination in France. It would be exceedingly interesting to hear the same subject dealt with from the standpoint of the petrol-air gas.

Among other communications of interest may be mentioned that of M. Cadenel on the manufacture of mantles for use with incandescent acetylene burners. The manufacture of these mantles presented peculiar difficulties, partly owing to the great heat of combustion of the mixture of acetylene and air used in these burners. It was also found that the small size led to special difficulties which had to be overcome by special design in a manner made clear by M. Cadenel in his paper. There were also papers dealing with recent types of acetylene burners, and statistical data relating to the acetylene industry in France.

List of References:—

ILLUMINATION.

Black, N. M. Illumination of Test-Types by Artificial Light (*Optical Journal*, U.S.A., June 11).

Editorials. The Use of the Term "Light-flux" in Illuminating Engineering (*Elec. World*, May 23).
The Mechanical Equivalent of Light (*Elec. Rev.*, N.Y., May 30).
The Quality of Artificial Light (*Elec. World*, June 6; *Elec. Rev.*, N.Y., May 23).

Nichols, E. L. Daylight and Artificial Light (*T.I.E.S.*, May).

Ryan, W. D'A. Illuminating Engineering (Nat. El. Convention, *Elec. Rev.*, N.Y., May 30).

Sorber, J. J. Relation of Direction of Light to Human Construction (*T.I.E.S.*, May).

Stockhausen, K. Moderne Schaufensterbeleuchtung (*J. f. G.*, June 1).

Weinbeer, E. W. Uniform Illumination of Horizontal Planes (*Elec. World*, May 23, letter).

Wohlauer, A. A. Uniform Illumination of Horizontal Planes (*Elec. World*, May 30).

PHOTOMETRY.

Hart, J. H. Photometers (*Elev. Rev.*, N.Y., May 23).
Kenelly, A. E., and Whiting, S. E. Some Observations on Photometrical Precision (paper read before Nat. Elec. Convention, *Elec. Rev.*, N.Y., May 30).
Lautsch. Ein neues Photometer (Elek. Ges. zu Cöln, *Elek. Anz.*, June 11).
Paulus, C. Vergleich der verschiedenen technischen Methoden zur Bestimmung der mittleren Horizontallichtstärke von Metalfadenlampen (*Zeit. f. Bel.*, June 20).

ELECTRIC LIGHTING.

Brady, J. E. The Law of Electric Light Companies (*Elec. World*, June 6).
Doyle, J. The Overshooting of Tungsten Lamps (*Elec. World*, May 30, letter).
Editorials. Progress in Incandescent Lamp Construction (*Elec. Rev.*, N.Y., June 6).
The Introduction of Tungsten Lamps (*Elec. World*, June 6).
Specifications for Street-lighting—Report of Committee of the National Electric Light Association. *Elec. World*, May 30).
Henry. Applications d'Électricité dans les Eglises (*L'Electricien*, June 20).
Kellog, C. W. Various Forms of Electrical Illuminants and their Efficiency (*Am. Gaslight Journal*, June 1.
Mackenzie, J. D. Electricity or Gas? The Problem of the Small Consumer (*Elec. Rev.*, June 12).
Taylor, J. B. Overshooting of Tungsten Lamps (*Elec. World*, May 23).
Vogel, O. Die Wanderung des Elektrischen Lichts von der Kohle zum Metall (*Z. f. B.*, May 30 and June 10).
Wohlauer, A. A. Economical Aspects of various Illuminants (*Elec. World*, May 16).
Fortschritte in der Glühlampen-Industrie (*Z. f. B.*, May 30 and June 10).
Glühlampen-Messinstrument (*Oesterr.-Ungar Installateur*, May 23).

GAS LIGHTING,

Anzbock, J. Okonomische Vergleiche zwischen dem elektrischen Lichte und dem Gaslichte (*J. f. G.*, May 30).
Bunte, Meyer, and Teichel. Combustion in incandescent gaslamps (*G. W.*, translated from the *J. f. G.*).
McPherson, H. H. An oft-neglected Asset: The Old Consumer (*Am. Gaslight Journal*, May 18).
Lux. Compressed Gas or Compressed Air (*G. W.*, May 30, from the *Z. f. B.*).
Blau Gas: a New Gas for Illuminating, Heating, and Power Purposes (*G. W.*, June 20).
Einige Winke aus der Praxis über hochintensive Invertbeleuchtung (*J. f. G.*, June 13).
Gasfernzünden (*Oesterr.-Ungar Installateur*, June 6).

ACETYLENE LIGHTING.

Some papers read before the International Acetylene Congress.

Bingham, C. Acetylene or Petrol-Air Gas.
Cadenel. On the Manufacture of Mantles for Incandescent Lighting by Acetylene.
Granjon, R. Statistics on 10,000 Plants inspected by the Union of Owners of Acetylene Appliances in France.
Letang. Note on an Improved Manchester Burner.
Pitavel. Acetylene Lighting in Mines in France.
Schumacher-Kopp. The Illumination of the Locomotives on the St. Gothard Railway by Means of Acetylene.

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
Elektrot. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
Z. f. Bel.—*Zeitschrift für Beleuchtungswesen.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society.*

On Lighting.

(Paper read by Prof. H. Bohle before the Cape Town Local Section of the Institution of Electrical Engineers, February 10th, 1908.)

THE masterly paper recently read by Prof. H. Bohle, of the South African College, Cape Town, on this subject, suggests that the ever-growing interest in the subject of illumination in this country is shared by many in South Africa. The demands on our space prevent us from reproducing Prof. Bohle's paper, of which he has kindly sent us a copy, as fully as we should like to do. In what follows we append a short abstract, chiefly omitting those points which have recently been dealt with in *The Illuminating Engineer*. For further details we refer our readers to the original paper.

The subject of the paper is divided into four parts, entitled :—

I. Fundamental Conceptions.
II. Illumination of Buildings.
III. Outdoor Illumination.
IV. Illumination Photometers.

I. *General Considerations.*—The author commences by establishing the fundamental relation for the illumination, E, of a surface at a distance R from a source of intensity I, $E=\frac{I \cos \theta}{R^2}$, from which we may proceed to the well-known expression $E=\frac{I\,h}{(a^2+h^2)^{3/2}}$, for the illumination of a horizontal surface, at a distance a from a post of height h, at the top of which is placed the source of intensity I.

As an illustration of the use of this formula the author considers the illumination of a circular table of radius a, illuminated by a single source at a height h above it. In order to determine the height of the lamp giving the best illumination at the circumference of the table, we put $\frac{d\,E}{d\,h}=0$, and obtain the relation $a=\sqrt{2}\,h$. The actual illumination at the edge of the table is $0{\cdot}382\ \frac{I}{a^2}$, and at the centre it is $2\,\frac{I}{a^2}$.

The illumination from centre to circumference varies considerably, but can be made more uniform by the use of shades and reflectors. Evidently the ideal polar curve of illumination thus obtained from the source of light should approach the form $I=E\frac{(a^2+h^2)^{3/2}}{h}$.

Theoretically there need be no difficulty in securing a perfectly uniform illumination from a single source. The area that can be effectively illuminated by a single light depends upon the intensity of the source, its height from the ground, and the degree of illumination specified. As a rule $\frac{a}{h}$ is limited to 1·5 in the case of glow lamps, and to 3·0 for arc lamps.

Actually we usually utilize the effective illumination of several lamps, and we may study their combined illumination at various points by means of "contour-lines," in the manner suggested by Mr. A. P. Trotter and others. Prof. Bohle points out that the illumination midway between two lamps is either a maximum or minimum, according as $2a <$ or $> h\sqrt{h}$.

The contour lines of a single symmetrical source are circles. For two or more lamps they are more complicated. The best results, as regards uniform illumination, are to be secured by arranging the lamps at the corners of a series of equilateral triangles.

After discussing a number of other problems in illumination, the author concludes that, though *perfectly* uniform illumination is very difficult to obtain, there is no doubt that by standardizing the term $\frac{a}{h}$, and by the introduction of more symmetrically designed shades and reflectors, the present conditions might be very materially improved.

Very few sources yield a completely symmetrical distribution of light, but this does not very greatly interfere with the production of uniform illumination A more important factor is the effect of reflection from surrounding surfaces, walls of buildings, &c.

II. *The Illumination of Buildings.*—For the purpose of reading, an illumination of 50 lux suffices, while it should never be allowed to fall below 10 lux. For general illumination, however, 7 to 10 lux are enough. As a rule, the most important illumination is that in a horizontal plane, about table-height from the floor. But in special cases, such as picture galleries, provision must be made

for the illumination of surrounding objects.

In general we secure a good diffused illumination by employing a large number of scattered small units, and we may also utilize inverted arcs, which, however, entails a loss of 20 to 30 per cent. of the light in reflection. In calculating the effect of clusters of lamps we may assume the cluster to yield the sum of the mean hemispherical candle-powers of the individual lamps, minus a certain percentage to allow for the fact that each lamp tends partially to screen the light from the others. In the case of 2, 3, and 4 lights, we may deduct 12, 16, and 20 per cent respectively to allow for this. But, actually, such clusters are usually partially surrounded by shades and reflectors, and the resulting polar-curve of the combination must, therefore, be determined.

In shops, factories, and workshops, two kinds of illumination—that required for general purposes and that concentrated on the actual work—are usually necessary. This latter local illumination is best obtained by the aid of glow lamps.

The accurate predetermination of illumination in a building is necessarily interfered with to some extent by the influence of reflection from the walls of the room and the scheme of decoration adopted. In cases where the exact effects cannot be foreseen and allowed for, the author suggests that the best plan is to work out the results for a *black* room. The actual illumination will then be higher than intended, but this will be partially counterbalanced by the deterioration in lamps and reflecting surfaces with age. On the other hand, provided glow lamps are equipped with suitable diffusing shades and reflectors, the illumination cannot easily be made injurously great.

As a rough guide to the illumination required under various circumstances the author quotes the following figures, recommended by the A.E.G :—

	C.P. per sq. metre, floor space.
Private Houses.	
Drawing-room	4 to 5
Dining-room	3 to 3·5
Bedroom	1·5 to 2
Kitchen-room	1 to 2
Shops.	
Counter	4 to 7
Stores	3 to 3·5
Offices	5 to 6
Hotel.	
Concert Halls	9 to 13
Private Rooms	2 to 4
Meeting Rooms	5 to 7

The height of lamps in rooms less than 4 metres high is usually 2 to 2·5 metres. For rooms more than 7 metres high, a convenient height for the lamps is 0·4 times that of the room.

In factory yards we may likewise allow 0·3 to 0·5 candle-power per square metre floor space; in railway stations, market halls, and factories 0·5 to 1 candle-power, 1·5 to 2·5 candle-power, and 2·3 candle-power respectively.

III. *Outdoor Illumination.*—A great deal of doubt seems to exist in the minds of engineers with regard to the manner in which outdoor lighting is to be judged. Streets and squares are illuminated so as to enable people to recognize one another, to distinguish objects on the ground, and to read an address in, at least, some parts of the illuminated area. From this it might appear that a vertical plane would be best for testing the illumination. Against this stands the fact that a vertical plane may have different positions with regard to the incident rays, in some of which it might receive light only from one source, or from none at all, even though several sources take part in the illumination of the region into which the plane has been place d These disadvantages obtain more or less also for inclined planes, so that the horizontal alone is left, in which street lighting can be properly tested, and in which it should be judged.

As it is inconvenient to test the illumination of the ground, since one would have to kneel down with some photometers, the author proposes to determine the illumination of a plane one metre from the ground.

The illumination of a street or square is usually judged by that of the darkest part, *i.e.*, by its minimum.

This appears to be hardly correct for avenues which contains rows of trees, and would be unfair to the contractor. At the same time, we must not judge the lighting by the maximum illumination, as this would be unfair to the public, since, with a satisfactory maximum illumination, some parts of the illuminated area may be in comparative darkness.

To appease both parties the illumination should be judged by the average value, and then it is also possible to get an idea of the cost of outdoor illumination, which could be stated per lux per 100 square metres road surface. The uniformity of the lighting is expressed by

$$\frac{\text{maximum illumination}}{\text{mean illumination}}$$

and

$$\frac{\text{minimum.}}{\text{mean.}}$$

The more these two factors approach unity the greater is the uniformity of the illumination. Under (I) it has been shown how this result can be obtained.

Large squares and wide streets are best illuminated by arc lamps fixed about 15 metres above the ground. The best height would be 0·7 times the distance between adjacent lamps, but in this case we should get poles 30 and more metres high. In squares the lamps are best arranged at the corners of equilateral triangles, for streets above the middle of the road, if possible. The average illumination for main thoroughfares should not be less than 1 lux for side streets—it is often less than a tenth of this.

The determination of the average illumination may be accomplished by plotting illumination curves in various directions, and taking the mean value. Such a method is, however, extremely laborious. It is simplified by the assumption that the lights are symmetrical, and as most arc lamps are surrounded by diffusing globes, and as glow lamps are usually covered with shades, the error thereby introduced is not so very great, especially as, in any case, approximate results can be expected only.

The method is further simplified by dividing the street or square into a number of small squares. For the centre of each we determine with the aid of the polar curves the resultant illumination of all lamps taking part in its illumination, and afterwards take the mean. The method is not as laborious as it appears at first sight, especially if all the lamps are equally spaced, of the same type, and erected on poles of similar height. It is, at least, useful to check results of completed installations.

Dr. Bloch advocates a further simplification.* The street is divided into a number of equal squares, such that each one includes one lamp, or bracket, placed in the centre. The area of each square is then changed into an equal circular one, and it is assumed that no other lamp takes part in its illumination. This introduces two errors. By changing the rectangle into a circle and calculating the average illumination for the latter we obtain a value slightly too large. On the other hand, by neglecting the light from other sources, we obtain an average value somewhat too small. Both errors partly neutralize one another; the remainder may be expressed by a factor K, with which the calculated average value has to be multiplied in order to obtain the actual average illumination. For K Dr. Bloch gives the value (for street lighting) $K = 1{\cdot}2 - 0{\cdot}1\lambda$ where

$$\lambda = \frac{\text{distance between lamps}}{\text{width of street}}.$$

The distance between the lamps is measured in the direction of the street, even if the lamps are staggered.

The author then proceeds to deduce a number of mathematical expressions for the calculation of the mean illumination over a given area, and gives a number of practical examples illustrating their application to street lighting. Finally, he remarks that in these determinations, the reflection of light from adjacent buildings, &c., has not been taken into account. The effect of such reflection in different towns differs very greatly. Reflection from the buildings found in towns in South Africa, for instance, assists the general illumination considerably; in larger and dirty cities, on the other hand, the effect is comparatively trifling.

IV. *Illumination Photometers.*—In this section of his paper the author briefly summarizes the essential qualities of illuminometers, dividing these instruments into "diffused reflective" and "diffused transmission" photometers. He then proceeds to describe the well-known instruments of Weber, Brodhun, Martens, and Trotter. Finally, he describes the principles and use of the Ulbricht globe photometer, and makes brief reference to the integrating instruments of Blondel and Matthews.

* *Elektrotechnische Zeitschrift*, 1906, p. 493.

Middlesbrough Meeting of the Iron and Steel Institute.

THE annual meeting of the Iron and Steel Institute will be held at Middlesbrough on September 28th, 29th, and 30th, and October 1st.

A number of papers will be read, and other items on the programme will include a visit to the official opening of Smith's dry dock on the Tees; members will also be invited to luncheon by the Cleveland Institution of Engineers, and a garden party will be given by Sir Hugh and Lady Bell.

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

10,590. Incandescent lamp filaments. May 15. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
10,690. Incandescence lamps. May 16. E. A. Gimingham, Birkbeck Bank Chambers, London.
10,760. Luminous radiators. May 18. The British Prometheus Co., Ltd., G. Cooper and F. C. Sharp, 77, Colmore Row, Birmingham.
10,773. Lamp holders. May 18. A. F. Rock, 77, Chancery Lane, London.
10,808. Metallic filaments for incandescent lamps. May 19. C. H. Dorman, 82, Duckett Road, Harringay, London.
10,885. Filaments for incandescent lamps (C.S.). May 19. (I.C. Nov. 27, 1907, Germany.) Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.
10,889. Carbon holders for arc lamps (C.S.). May 19. (I.C. Nov. 29, 1907, Belgium.) R. Chaudet, 1, Queen Victoria Street, London.
10,891. Filaments for incandescent lamps (C.S.). May 19. (I.C. Oct. 7, 1907, Germany.) Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.
11,460. Incandescent lamps. May 26. The British Thomson-Houston Co., Ltd., and T. E. Robertson, 83, Cannon Street, London.
11,564. Carbon steadier for arc lamps. May 28. E. Cunningham, 31, North Terrace, Tarbrax, Cobbinshaw, Scotland.
11,600. Filaments of Chinese ink for incandescent lamps (C.S.). May 28. (I.C. Oct. 30, 1907, Germany.) K. Rittersberg and H. Rubert, 67, Knesebeckstrasse, Charlottenburg, Germany.
11,607. Illuminating billiard and operating tables, &c. May 28. E. R. Crook, 5, Carnaby Street, Regent Street, London.
12,194. Method of supporting lamp filaments. June 5. D. Murray, 3, Lombard Court, London.
12,225. Luminous lighting and bell switches. June 5. E. S. Conradi, 19, Ebbsfleet Rd., Cricklewood.
12,398. Metal filament lamp installations. June 9. W. Dierman, 18, Southampton Buildings, London.
12,470. Adaptor for incandescent lamps. June 10. F. L. Wright, 9, Warwick Court, Gray's Inn, London.
12,556. Arc lamp carbons (C.S.). June 11. Siemens Bros. Dynamo Works, Ltd., Queen Anne's Chambers, Westminster. (From Siemens Schuckert-Werke G. m. b. H., Germany.)
12,592. Push-switch lamp-holder. June 12. G. H. Ide, 152, Sherlock Street, Birmingham.
12,630. Pocket lamp (C.S.). June 12. P. M. E. Bourgeois and C. H. Bourgeois, 65, Chancery Lane, London.
12,644. Arc lamps (C.S.). June 12. J. O. Girdlestone and C. F. G. Thorkelin, 37, Warwick Rd., Ealing.
12,651. Arc lamps. June 12. Johnson & Phillips, Ltd., and S. Paterson, Birkbeck Bank Chambers, London.
12,654. Lamps. June 12. The London Import Co., Ltd., and B. Pordes, 28, New Bridge St., London.
12,656. Arc lamps (C.S.). June 12. (I.C. July 8, Germany.) D. Timar and C. von Dreger, 7, Southampton Buildings, London.
12,682. Arc lamps (C.S.). June 12. (I.C. July 15, Germany.) Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.

II.—GAS LIGHTING.

10,595. Anti-vibrators for incandescent burners. May 15. W. Sugg & Co., Ltd., and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.
10,613. Fittings of inverted incandescent lamps. May 15. J. Webber, 18, Southampton Buildings, London.
10,650. Gas and like burners. May 16. T. Westgarth and L. Taylor, Hartlepool Engine Works, Hartlepool.
10,688. Inverted incandescent lamps (C.S.). May 16. Actien-Ges. Schaeffer & Walcker and W. Schultze, 231, Strand, London.
10,856. Igniting street lamps (inverted incandescent) electrically (C.S.). May 19. F. T. Cotton, 8, Quality Court, Chancery Lane, London.
10,932. Inverted incandescent lamps. May 20. C. W. Harrison, 96, Middlesex Street, London.
11,034. Incandescent mantles. May 21. N. Gödelmann, 19, Farringdon Street, London.
11,122. Incandescent burners (C.S.). May 22. H. W. Lake, 7, Southampton Buildings, London. (From Neue Kramerlicht-Ges. m.b. H., Germany).
11,152. Incandescent mantles (machines for tying) (C.S.). May 22. S. Cohn, 11, Southampton Buildings, London.
11,349 Inverted incandescent burners. May 25. W. B. Smith, 66, College Street, Chelsea, London.
11,635. Inverted incandescent burner. May 28. A. S. Francis, 77, Chancery Lane, London.
11,942 Inverted incandescent burners (C.S.). June 2. A. L. Dunphy and J. Tysoe, 163, Queen Victoria Street, London. (Addition to 20/07.)
12,146. Incandescent lamps. June 4. A. C. Noad, 18, Louvaine Road, St. John's Hill, Clapham Junction, London.

12,154. Reflector for inverted lamps. June 4. E. Hendrichs, 345, St. John's Street, London.
12,193. Inverted incandescent burners. June 5. G. Hands, 71, Farringdon Road, London.
12,278. Fittings for incandescent burners. June 5. J. Booth, trading as Samuel Booth & Co., and R. J. Simpson, 35, Temple Row, Birmingham.
12,331. Inverted incandescent lamp. June 6. H. O. Klauser, 116, High Holborn, London. (From Automatic Screw Works, Holland).
12,377. Incandescent burners. June 9. J. Cronin, 100, Wellington Street, Glasgow.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

10,662. Burners of reading lamps (C.S.). May 16. G. Baker, King Edward Street, Whitland, Carmarthenshire.
10,682. Acetylene lamps. May 16. H. Cole, 77, Colmore Row, Birmingham.
10,696. Lamp. May 16. J. S. Burns and the Sylverlyte Electric Lamp Co., Ltd., 173, Fleet Street, London.
10,707. Lamp globe (C.S.). May 16. O. A. Mygatt, 322, High Holborn, London.
10,708. Reflector (C.S.). May 16. O. A. Mygatt, 322, High Holborn, London.
10,715. Automatic igniters and extinguishers (C.S.). May 16. M. W. Bröndum, 345, St. John's Street, London.
11,054. Lenses for motor and other lamps (C.S.). May 21. A. R. Cosgrove, 19, Holborn Viaduct, London.
11,126. Globes for inverted lamps. May 22. J. Webber, 18, Southampton Buildings, London.
11,237. Petroleum lamps (C.S.). May 23. C. Schmölcke, 231, Strand, London.
11,301. Incandescent light economizer. May 25. E. C. Felstead, F. C. Finney, and R. C. Lamond, 39, Chatham Avenue, Murray Street, Hoxton.
11,772. Flash advertising signs. May 30. G. Sweetser, 11, Southampton Buildings, London.
12,210. Oil lamps. June 5. J. McNair, 154, St. Vincent Street, Glasgow.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

11,979. Arc lamp electrodes (C.S.). I.C. Jan. 29, 1907, Germany. Accepted May 20, 1908. Deutsche Beck-Bogenlampen G. m. b. H. and H. Beck. Thanet House, Temple Bar, London.
12,369. Arc lamps. May 28, 1907. Accepted June 3, 1908. A. H. Brzeski and A. Strauss-Collin, 27, Chancery Lane, London.
12,902. Enclosed arc lamps. June 4, 1907. Accepted June 3, 1908. B. A. Quint, "Maybury," Audley Road, Hendon.
15,798. Incandescent lamp with metal filament (C.S.). I.C. May 31, 1907, Germany. H. Kuzel, 322, High Holborn, London.
18,742. Arc lamps (C.S.). Aug. 20, 1907. Accepted May 20, 1908. W. G. Heys, 51, Deansgate Arcade, Manchester. (From the Scott Electrical Co., U.S.A.)
19,734. Arc lamps. Sept. 4, 1907. Accepted June 11, 1908. O. Gross, 5, John Dalton Street, Manchester.
23,585. Metal filaments (C.S.). Oct. 30, 1907. Accepted May 27, 1908. Glühlampenwerk Anker G. m. b. H., 65, Chancery Lane, London.
27,739. Arc lamp (C.S.). I.C. Dec. 20, 1906, Germany. Accepted May 20, 1908. F. Janecek, 27 Chancery Lane, London.
28,451. Lengthening life of incandescent lamps (C.S.). Dec 27, 1907. Accepted May 20, 1908. W. Herrmann, 40, Chancery Lane, London.
66. Arc lamp electrodes (C.S.). I.C. Jan. 5, 1907, U.S.A. Accepted June 3, 1908. G. M. Little, Westinghouse Patent Bureau, Norfolk Street, Strand, London.
2,481. Holders for incandescent lamps (C.S.). Feb. 4, 1908. Accepted May 27, 1908. Siemens Bros. Dynamo Works, Ltd., and H. C. Wheat, 139, Queen Victoria Street, London.
2,569. Incandescent lamps, and shades or reflectors (C.S.). Feb. 5, 1908. Accepted May 20, 1908. J. J. Rawlings and R. T. Smith, 34, High Holborn, London. (Addition to 8,151/07.)
5,225. Arc lamp electrodes (C.S.). I.C. July 5, 1907, Germany. Accepted June 11, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
5,610. Incandescent lamps (C.S.). I.C. March 14, 1907, Germany. Accepted June 11, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
8,421. Filaments for incandescent lamps (C.S.). I.C. May 13, 1907, Germany. Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.

II.—GAS LIGHTING.

10,975. High pressure lighting apparatus. May 10, 1907. Accepted May 20, 1908. W. Edgar, 173, Fleet Street, London.
12,354. Incandescent burners. May 28, 1907. Accepted June 3, 1908. F. Turner and G. Hands, trading as G. Hands & Co., 77, Chancery Lane, London.
14,158. Incandescent burners. June 19, 1907. Accepted May 20, 1908. S. Holman, 27, Chancery Lane, London.
19,811. Incandescent lamps. Sept. 4, 1907. Accepted June 3, 1908. C. W. Harrison and A. C. Noad, 7, Southampton Buildings, London.
23,267. Inverted incandescent burners. Oct. 22, 1907. Accepted May 20, 1908. J. W. Bray, Sunbridge Chambers, Bradford, Yorks.
27,490. Inverted incandescent burner (C.S.). I.C. Dec. 12, 1906, France. Accepted June 3, 1908. M.-A. Robert, 18, Southampton Buildings, London.

27,939. Incandescent mantles (C.S.). I.C. Dec. 18, 1906, Germany. Accepted May 20, 1908. W. Huber, 72, Cannon Street, London.
1,074. Incandescent burners (C.S.). Jan. 16, 1908. Accepted May 20, 1908. A. Pöschl, Thanet House, Temple Bar, London.
2,973. Inverted incandescent pressure lamps (C.S.). I.C. Feb. 26, 1907, Germany. Accepted June 11, 1908. M. Graetz and A. Graetz, trading as Ehrich & Graetz, 18, Southampton Buildings, London.
4,451. Nozzles for inverted incandescent burners (C.S.). Feb. 27, 1908. Accepted June 3, 1908. M. Graetz, 18, Southampton Buildings, London.
5,031. Incandescent lamps. March 5, 1908. Accepted May 27, 1908. E. H. Still, 46, Lincoln's Inn Fields, London.
5,273. Supporting incandescent mantles in vertical lamps (C.S.). March 9, 1908. Accepted June 11, 1908. B. A. Manning, "Montrose," South End Road, Hampstead.
10,782. Nozzle for inverted lamps (C.S.). I.C. May 17, 1907, Germany. T. Eberhard, 56, Myddelton Square, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

13,477. Combined upright and pendant incandescent vapour and gas burners (C.S.). June 11, 1907 Accepted May 27, 1908. M. W. Pitner, 615 F Street, N.W., Washington, D.C., U.S.A.
15,029. Lamp shades and lenses. June 29, 1907. Accepted June 11, 1908. T. Ward and M. Cooper, 173, Fleet Street, London.
15,851. Street lamp post and fittings. July 10, 1907. Accepted May 20, 1908. H. Hallows, 3, Gore Street, Greenheys, Manchester.
19,986. Wax-burning lamps. Sept. 7, 1907. Accepted May 20, 1908. C. E. Baxter, Victoria Chambers, Martineau Street, Birmingham.
3,163. Acetylene lamps (C.S.). Feb. 12, 1908. Accepted June 11, 1908. L. Jouvenet, Birkbeck Bank Chambers, London.
8,746. Incandescent filaments (C.S.). April 21, 1908. Accepted May 20, 1908. G. Auger, 18, Southampton Buildings, London.
8,960. Lanterns (C.S.). April 24, 1908. Accepted June 3, 1908. J. B. Brantingham and W. P. Brantingham, trading as Brantingham Bros., 4, South Street, Finsbury.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.— Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

TRADE NOTES.

The Lighting Department of the G. E. C. have sent us an illustrated pamphlet describing the new "*tungsten economy diffusers*" manufactured by the company specially for use in diffusing the light from tungsten incandescent lamps and softening their intrinsic brilliancy. The shades are also claimed to be effectual in distributing the light in the desired directions, and can be made to include groups of five or six lamps.

The "METALLINDUSTRIELLE RUNDSCHAU," of Berlin, draw our attention to an illustrated list of the complete series of glass chimneys of various shapes manufactured by Jacques Goldberg. The pamphlet contains exact measurements and illustrations of upwards of 240 different models, and serves to show the variety of globes and chimneys available for use with different oil-lamps, and the care necessary in order to make the best selection.

We have received a booklet describing the "*Chlorophylle*" tinted glasses, in which an attempt is made to give to eye-protectors, spectacles, &c., a greenish-yellow tinge of colour which is claimed to be advantageous from the hygienic standpoint. It is asserted that by this means a sensation of restfulness when observing bright lights coupled with sufficient luminosity and remarkable clearness of vision is obtained. The makers are J. B. JACQUEMIN BROS., LTD., 65, Hatton Garden, London.





The
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EDITORIAL.

Expert Knowledge applied to Public Lighting.

CONSIDERING the immense amount of money spent annually on public lighting one would naturally suppose that the method of lighting adopted in any particular case would be the subject of very careful consideration, and that before embarking on any such enterprise, those responsible would avail themselves of the best expert opinion and would take pains to secure that the system adopted was the best that could possibly be devised to meet the circumstances of the case.

Actually we know that this is, unfortunately, often very far from being the case, and that street-lighting is often regarded as a mere matter of whim or is determined by outside considerations quite apart from the really important factors in the situation. We notice, however, a striking instance to the contrary in the deliberations of the Finance Commission of Boston. The commission have definitely decided to withhold their report on the street-lighting of that city until the opinions of their expert representatives, specially visiting the chief cities of Europe for the express purpose of studying the most recent methods of street-lighting, are available.

During the last two months we have recived visits from Mr. G. U. Crocker, a member of the commission, and two appointed experts, Dr. Louis Bell, who, of course, is well known to our readers as the president of the Illuminating Engineering Society, and is also consulting engineer to the Edison Electric Co., and Mr. Whittington of the Boston Consolidated Gas Co., who were visiting London for this purpose.

To our mind this is a most interesting example of the value that is attached to expert knowledge in the United States. And it is not only the fact that the Finance Committee think fit to authorize such investigations by acknowledged experts in both gas and electric lighting that strikes us as so admirable. Dr. Bell and Mr. Whittington, though connected with electrical and gas companies respectively, are

visiting Europe not as electric or gas, but as *illuminating engineers*. They are anxious to learn all that is to be learnt about the progress of both illuminants.

As a result it may be expected that the matter will be taken up and considered by men who are in touch with the whole subject, and the discussion will not degenerate into a mere controversy between representatives of gas and electric lighting who understand their own systems and do not know—and do not care to know—anything of others. Whatever the issue in this case, we can only admire the evident pains that are being taken by the authorities, and do not doubt that their wide view of the subject will be amply justified by the ultimate result.

The Education of the Gas Engineer.

Our contemporaries *The Gas World*, and *The Journal of Gaslighting*, and other periodicals, have recently commented upon the strides that have been made in the training of gas engineers in Germany as exemplified by the magnificent facilities offered to those in the profession at the Technische Hochschule at Carlsruhe under the professorship of Dr. Bunte, and also at Munich, Dessau, Bremen, and elsewhere.

At the present day the complexity of problems that expert gas engineers are called upon to solve is such that the very highest scientific attainments are required and a scientific education becomes a necessity. The recent appointment of Prof. Bone to the Chair of Fuel at the University of Leeds is an indication that this necessity is becoming generally realized. Actually the whole field, both of gas and of electrical engineering, is so wide that a certain degree of specialization becomes a necessity, and it must be realized that the engineer whose attention is concentrated upon the many problems connected with the generation of gas or electricity may not be able to give the necessary study to the equally important illuminating side of the profession. It must not be forgotten that the great bulk of the gas and electricity generated is used simply for purposes of illumination, and the study of the conditions at the consumer's end demands constant care and judgment. There is sometimes a danger that problems of generation and distribution may be studied to the exclusion of the important aspects of the subject with which we are mainly concerned.

We notice that a scheme of co-operation has now been adopted between the examining authorities of the City and Guilds Institute and the Institute of Gas Engineers, and that a wise decision has been arrived at to separate the subject of gas engineering pure and simple from the subject of the distribution and utilization of gas. We hope that in this latter section the subject of illumination will receive the attention that its importance demands.

It is also interesting to recall that the general report of the Institution of Electrical Engineers for the present year made mention of a similar decision on the part of the Council to co-operate with the City and Guilds Examination Department, and to nominate representatives in different districts to attend the practical examinations. The revision of the syllabus for the examination of wiremen has recently formed the subject of discussion, and we hope that the interest of the Institution in the matter will secure that the subject of illumination receives adequate consideration.

Another instance of the movement towards better methods of educating the rank and file of the profession is afforded by the agreement between the Gas Light and Coke Co. and the London County Council to organize special courses in gas engineering for the benefit of those wishing to enter the profession. It seems to us that a great opportunity for giving valuable training in the fundamental principles

of good illumination is here presented. In previous correspondence we also had an opportunity of satisfying ourselves that the Education Department of the L.C.C. would be willing to pay attention to the subject of illumination, and we feel confident that any desire to organize courses of instruction of this nature would be sympathetically regarded. There is no need for any very elaborate instruction in theoretical aspects of the subject that are better left to the judgment of professors. But there certainly is room for instruction on practical and commonsense lines in the measurement of light and the utilization of it to the best advantage, and there can be no doubt that any trouble expended in this way would be well repaid in the future.

Public Interest in Architecture.

We observe that Mr. Delissa Joseph has addressed a letter to *The Times*, pleading for a more general recognition of the principles of architecture by the general public. He points out the City of London is slowly developing into one of the most beautiful capitals in the world, and the present rate of progress might be appreciably accelerated if the municipal patriotism and the enthusiasm for artistic productions, characteristic of many of the Continental cities, were more developed in our own city.

We ourselves sympathize with this desire, and we have frequently drawn attention to the need for a better understanding of these very principles by which architects are guided among those concerned with artificial illumination. But the exceedingly important question of the correct methods of lighting fine buildings so as to carry out the feeling and intentions of the architect responsible for their design, can only be met by joint action between the architect and the lighting engineer.

In this connexion the subject dealt with in one of the articles in our special section is of exceptional interest. Naturally the value, during the night-time, of graceful and artistic buildings is entirely subservient to the illumination by the aid of which they are rendered visible. If, therefore, as will hardly be contested, there are buildings in the streets of London of exceptional architectural and historic interest, why is not the illumination of the exteriors of these buildings, with a view to bringing out their most interesting features to the best advantage, more seriously studied? Moreover, when we bear in mind that artificial light, unlike daylight, is under control, and that we can arrange our sources so as to produce practically any play of light and shadow that the character of the building may require, one would suppose that the scientific use of artificial light in this way might lead to very fine artistic results indeed. Especially is this true as regards the lighting of buildings in exhibitions, &c. A great section of the public only enter an exhibition during the evening—indeed the illumination is a great attraction. Surely, therefore, the proper method of lighting the buildings on which so much careful design has been expended should be a matter of very careful study, and some definite agreement should be reached as to what the best method really is.

The study of illumination ought, therefore, to form an integral portion of the training of the architect, just as the study of artistic principles is essential to the illuminating engineer, in order that both may work together for a common end.

The Colour-Revealing Qualities of Different Illuminants.

In our last number we referred to some conflicting statements regarding the effects of different illuminants on eyesight; in this case we wish to draw attention to another matter on which an authoritative statement is needed, namely, the effect of different forms of artificial light on coloured

objects. We note, for instance, that one of the notices outside the Machinery Hall of the electrically illuminated "Ideal Home" in the Franco-British Exhibition says of the electrical glow-lamp that "of all artificial light, it most closely resembles sunshine." In his recent paper on acetylene and petrol-air gas, Mr. Bingham likewise referred to acetylene as the nearest to sunlight of all illuminants.

The author of the article on stage-lighting in the present number, on the other hand, mentions that arc-lights are deliberately employed on the stage for imitating daylight in preference to glow-lamps. Yet we frequently hear the tungsten lamp spoken of very favourably for this purpose. It will also be remembered that Mr. Moore (*Illuminating Engineer*, Feb. 1908, p. 161), was so convinced of the exact resemblance of the carbon-dioxide Moore tube to daylight that he recommended its use as a standard.

The Spectra of Artificial Lights.

After what has been said in the last paragraph on the divergency of the views expressed on the subject of the appearance of colours as seen by the light from various sources, it may be of interest to turn to the valuable paper recently read before the Illuminating Engineering Society by Dr. Nichols. There can be no doubt but that the quantitative measurement of the intensity of the light in various regions of the spectra of different illuminants is the true scientific guide to the study of problems of this nature. Briefly, Dr. Nichols explains that although daylight itself differs considerably under different natural conditions, yet there is no serious difficulty in forming a fairly correct conception as to what is really meant by the quality of light we term "daylight," for purposes of comparison with different illuminants.

We may, of course, set aside at once sources of light that do not give a continuous spectrum, such as the mercury vapour lamp, and to a less degree the flame arc, as abnormal and out of the question where the correct delineation of delicate shades of colour is concerned. Among the continuous spectra we remark that the chief defect in all artificial illuminants would seem to be a lack of strength in the blue. In cases where a strong blue element is present, we sometimes find it in the form of a localized bright band, which will probably have the effect of distorting the appearance of coloured objects even more than a uniform weakness. We can readily understand, for instance, that the peak in the curve showing the spectrum of the arc-light would have this effect. The older incandescent mantles likewise suffered from a peak in the curve, which interfered with the correct presentation of colours.

It is, however, encouraging to find that we are making progress towards the desired type of illuminant. The general resemblance of the spectrum of the acetylene flame to that of daylight is distinctly closer than that of the old gas-flame. Similarly the tungsten lamp is in this respect a marked advance on the carbon lamp; it would be even more interesting to see the corresponding curve for the Helion filament.

Whatever be the means by which we ultimately attain our goal there can be no question of the importance of exact knowledge on this point. Mr. Middleton, in his article on the lighting of picture-galleries, makes reference to the need for an illuminant resembling daylight exactly, and such a source of light would be of the very greatest assistance to artists, and, in fact, in any case in which the correct representation and distinction between delicate shades of colour is desired.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter brings the theoretical parts of his articles to a conclusion in the present number. The final section deals with some SPECIAL CASES OF DISTRIBUTION, and points out the claims of illumination in a vertical and horizontal plane respectively, under various conditions. A comprehensive diagram of five illumination-curves is given.

The next part of these articles will deal with PHOTOMETRIC INSTRUMENTS AND METHODS.

Prof. J. T. Morris describes the results of some TESTS ON HIGH-AND LOW-PRESSURE GAS-LIGHTING. He expresses his results in mean spherical and mean hemispherical candle-power, and points out the inconvenience resulting from the selection of the intensity in one particular direction only as a basis of comparison. He likewise refers to the effect of fluctuations of pressure on the performances of gas-lamps and the need for specifying the calorific value of the gas used. He states, for instance, that the maximum candle-power of a lamp was found to be 1,250 in one part of London and 800 in another, owing, presumably, to a difference in the quality of the gas supplied.

Mr. B. Duschnitz describes a NEW FORM OF MERCURY-CARBON GLOW-LAMP that has been developed in Germany. The filament of the lamp is composed of carbon, but burns in an atmosphere of mercury vapour instead of in vacuo, as in the case of lamps of the ordinary variety. This atmosphere of mercury vapour is secured by the volatilization of a drop of mercury placed within the U-tube containing the filament. The lamp is said to consume about 1·5 to 1·7 watts per c.-p., and such results as are at present to hand regarding the life of the lamp are looked upon as satisfactory.

The author quotes the results of a series of experiments by Dr. Lux, having for their object to determine whether the increase in efficiency is to be ascribed to high temperature or luminescence. The conclusion is reached that the former explanation is the correct one, the envelope of hot mercury vapour restricting the conduction of heat from the filament and so raising its temperature of incandescence.

Mr. G. A. T. Middleton deals with the LIGHTING OF PICTURE GALLERIES. He points out that the artificial lighting of picture galleries is an important question, inasmuch as many people who are unable to pay attention to the subject in the daytime might be willing to visit our national collections by night. One of the most vital and essential qualities of an illuminant intended for picture-lighting is perfect safety. We must also feel certain that the source of light gives off no injurious fumes or rays of a nature likely to injure the often priceless and unique objects of art that are to be illuminated.

Other very important considerations are the provision for an adequate diffused illumination, so that all pictures may be evenly illuminated and that there may be no reflection from the glass, and the choice of an illuminant that does not unduly distort the colours.

Dr. C. V. Drysdale completes his survey of the existing methods of determining LUMINOUS EFFICIENCY AND THE MECHANICAL EQUIVALENT OF LIGHT. He gives a comprehensive list of the results obtained by previous workers in the subject and also his own determinations for white and yellow-green monochromatic light; he further suggests that an ideal source of white light ought to give us at least 10 candles per watt, while from a monochromatic light nearly 17 candles per watt should be obtained.

Dr. Drysdale's next instalment will deal with 'THE LAWS AND MEASUREMENT OF RADIATION.'

The Special Section in the present number is devoted to ILLUMINATION AT THE FRANCO-BRITISH EXHIBITION. The first of the two articles dealing with the subject describes the chief objects of interest from the standpoint of illumination, while the second

contains some discussion on the general principles underlying the illumination of the grounds and buildings of an exhibition. Naturally the illumination both of the grounds and buildings and also of particular exhibits opens up a great field for ingenuity in order to secure special effects, such as cannot be obtained under ordinary circumstances.

The writer of the second of the two articles referred to suggests that the present traditionally accepted method of outline-lighting of buildings does not lead to the most perfect æsthetic effects, partly because the small unshaded glow-lamps are apt to be wearisome to the eye, and also because the method does not facilitate the revealing of light and shadow, on which the architectural charm of a building so greatly depends. He therefore prefers an attempt to imitate daylight-illumination to the extent of illuminating the building as a whole by external sources, and illustrates his contentions by several photographs of illumination-effects of this nature.

Among other articles in this number may be mentioned that on STAGE-ILLUMINATION. The author discusses the purposes which artificial light employed on the stage is intended to serve, and describes the various fixtures and arrangements of glow-lamps by the aid of which the main illumination is secured. Special interest attaches to his description of the use of arc-lights and coloured lamps of various kinds so as to imitate natural phenomena—dawn, moonshine, driving clouds, &c.

Electric lighting, the author states, is now practically exclusively used for theatre illumination, and it isinteresting to note that nearly 3,000 glow-lamps are used for the lighting of the stage of the theatre at Frankfort alone.

An article on SHADES AND REFLECTORS describes some of the objects to be served by glass-ware applied to the distribution and diffusion of light, and describes some of the types developed by the Holophane Company for this purpose.

Another contribution deals with the LIGHTING OF RAILWAYS BY ACETYLENE. The author describes the four chief methods of acetylene lighting employed on trains at the present day. He distinguishes between the lighting of railway stations and carriages, and gives a number of instances in which the use of dissolved acetylene enabled a train to continue to give the requisite illumination for a long period of time at a stretch without recharging. Acetylene lighting, it is stated, is already extensively employed for the purpose of illuminating railway carriages in the United States and Canada, and is also either in actual use or under consideration on many of the railway lines in Austria-Hungary, Italy, France, and Russia.

Mention may also be made of a description of the form of LIQUID GAS recently developed by **Mr. L. Wolf**, of Zürich. Like dissolved acetylene, this gas is enclosed under pressure in suitable receivers and liberated as required.

In the present number will also be found a very important and interesting paper, recently delivered by **Dr. E. L. Nichols**, before the Illuminating Engineering Society of New York, dealing with the COLOUR OF DAYLIGHT AND VARIOUS ARTIFICIAL ILLUMINANTS. He gives a number of curves showing the composition of daylight under different circumstances and in different localities, and also a comprehensive comparison of the spectral composition of many illuminants, ranging from the oil-flame to the most recent electric flame-arcs, &c.

Many readers will also be interested in the résumé of the annual meeting of the Société Technique du Gaz, and the Report of the Photometric Committee of the Deutscher Verein von Gas- und Wasserfachmännern, likewise published in the present number.

Attention may also be drawn to some **Correspondence** on the subject of **Mr. Voysey's** REPORT ON THE CITY LIGHTING, and on **Mr. Bingham's** recent paper on ACETYLENE AND PETROL-AIR GAS.

At the conclusion of the number is to be found the usual **Review of Current Literature** dealing with illumination and the **Patent List**.

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 538.)

Although the calculation of the true mean has been discussed here at some length, this quantity must be accepted with caution as a criterion of the useful or practical illumination of any particular case. It is quite possible to have cases which agree closely in mean illumination, but which may differ largely in useful effect. It is, for example, easy to see that a street may be lighted by powerful lamps widely spaced, while another may be provided with a large number of small lamps. The two might yield the same mean. In the former case there would be a useless superfluity of light near the lamps and intervals of very low illumination, while the latter would have a more uniform distribution of illumination, only slightly exceeding the mean in some places, and having no very low illumination at all. Let it always be remembered that theory in such cases cannot be allowed to override the commonsense opinion of a man of ordinary intelligence.

Reference has been made to the proposal to consider the difference between the brightest and the dimmest parts of an illuminated area, as a measure of the quality of the distribution (p. 447). Many other considerations have to be weighed in determining the best way of carrying out practical cases of lighting, but for what it is worth, this difference is represented for the cases shown in Figs. 10, 11, 12, and 13, by the curves of maxima and minima in Fig. 42. The way in which this difference increases with the wider spacing of the lights is worth noticing, but it conveys no useful information as to the area which is illuminated.

General Cases of Distribution.—The theoretical treatment has been confined thus far in these articles to the distribution of illumination on a horizontal plane. Whether that is the best or, indeed, an intelligent way to consider practical cases of illumination has been the subject of no little controversy. When the practical modes of measurement are discussed in a later section, something more will be said about the matter, but it is obvious that for the elementary consideration of distribution of illumination, it has been desirable to take the most simple cases first.

For interiors of large buildings such as railway stations the illumination of walls is quite as important as the illumination of the ground, and in the open street, any one who wishes to consult his watch will not hold it horizontally, but with the face turned

towards the light. In a railway goods-yard the illumination on the ground is practically of no consequence, but the lighting of the sides of the waggons is very desirable. No general rule can be laid down, but for ordinary street work it appears to be best to aim at a fair illumination of the ground, this being the most difficult. Practical measurement may conveniently be made at a height of 4 ft. from the ground, but this will be discussed later.

For any source of light, and at any given distance from that source, and with a screen which may be turned at any angle, the illumination of the screen will be greatest when it is turned full to the light, so that the light falls

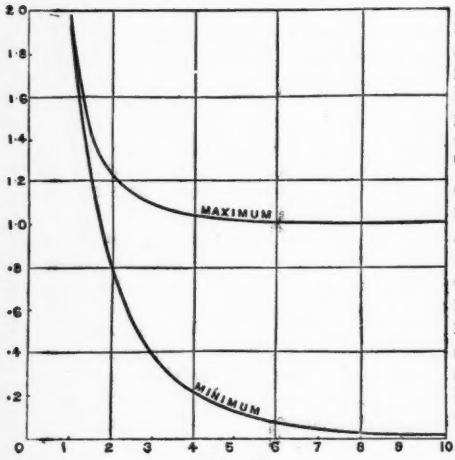


FIG. 42.

perpendicularly on it. The illumination is then inversely as the square of the distance, or, according to the convention assumed in these articles (the height of the source being unity), as the square of the cosine of the inclination of the ray to the vertical. The curve of cosine squared is given in Fig. 43.

The illumination of the vertical plane, the height of which is small compared with the height of the lamp, for example, the side of a truck in a goods-yard lighted by high lamps, is proportional to the product of the sine of the angle of incidence into the square of the cosine. This curve is given in Fig. 43. It will be noticed that it is zero below the lamp, and is equal to the illumination on a horizontal plane at 45 degrees. In other words, the illumination on the top and on the side of a small cube placed on the ground at this position would be the same. At greater distances the curve continually approaches the curve of the squared cosine. The illumination on the wall of a house facing a lamp, and at a distance measured by the angle of incidence of a ray striking its foot, follows the square of the cosine on that part which is level with the light (that is, inversely as the distance), and falls off to the product of the sine into the square of the cosine at the foot of the wall.*

Precisely the same law is followed in the variation of the illumination at a given point, when a lamp in the neighbourhood is placed at different heights in a perpendicular line. This is one of the few theorems of illumination which are to be found in text-books. The curve in Fig. 44 is the same as the $\cos^2\theta \times \sin\theta$ curve of Fig. 43. It represents the illumination at the point A by a source of light placed at different heights in the vertical line BC. This diagram differs from the preceding ones in these articles, since the illumination is here measured along a horizontal scale instead of a vertical. The vertical scale in Fig. 44 represents the variable height of the source of light. When the light is low the illumination at A is feeble, in spite of the proximity of the light, because the angle of incidence is so great. As the light rises this angle is reduced, and the illumination at A increases, until the light reaches the point D. It is then a maximum, and it may be shown that $BA = BD \times \sqrt{2}$, the angle of incidence BDA being 54° 44. It will

* Since the practical section of these articles will contain no reference to cases of purely horizontal illumination, it may as well be recorded here that such cases exist. Passengers on the tops of omnibuses, the audience in the gallery of a theatre, readers consulting books in the upper gallery of a library receive practically horizontal illumination. The sentry at the west entrance to Wellington Barracks enjoys horizontal illumination from the considerable number of electric arc lamps in front of Buckingham Palace.

be observed that a small change in the height BD may be made without appreciably altering the illumination at A. If the height be increased, the illumination will be diminished, owing to the increased distance.*

lamp situated at any point in the line CB. The practical application for lighting a desk by means of one or two lamps, which are conveniently placed otherwise than immediately over the middle, is obvious.

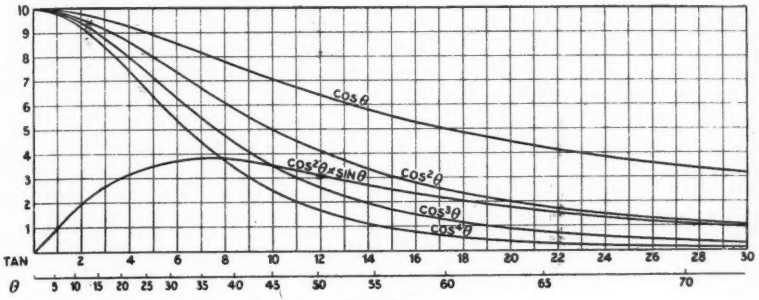


FIG. 43.

This maximum illumination of a point has been misunderstood. There is no special virtue in the angle of incidence whose tangent is $\sqrt{2}$, and it cannot be deduced that when lamps are arranged so that each one commands a circle of radius $\sqrt{2}$ (the height being unity), it is more "efficiently" illuminated than any other. The illumination of the circumference of such a circle is very nearly 0·2 of the maximum. The total light falling within the circle is 0·427 of the whole light falling on the horizontal plane. The distribution produced by several lamps in a row, each being $2\sqrt{2}$ apart, would closely resemble that represented in Fig. 12, p. 271. The characteristic would resemble $d = 3h$ in Fig. 37, p. 538. The usefulness of this arrangement is really limited to the particular case represented in Fig. 44, viz., the maximum illumination of the point A by a

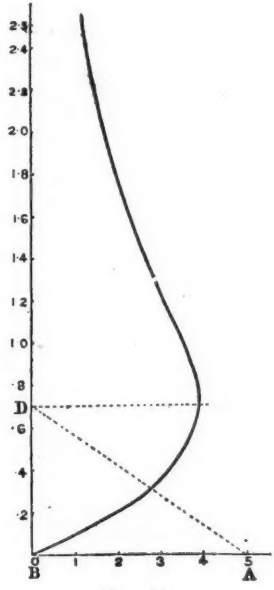


FIG. 44.

* It may be remarked that the $\cos^2\theta \times \sin\theta$ curve is the slope or differential of the $\cos^3\theta$ curve, the maximum ordinate occuring at the point of inflection, when $3\cos^2\theta = 1$.

(To be continued.)

The Report of the Photometric Committee of the Deutscher Verein von Gas- und Wasserfachmännern.

THE numerous technical committees of the German Society of Gas Engineers have now reported, and among these reports special interest attaches to that on Photometry, presented by Dr. H. Krüss.

The question was raised whether the photometric rules adopted by the German Institution of Electrical Engineers could be applied to gas-lamps, or whether any modification was desirable.

The most important recommendation embodied in the report is that specifying the mean lower hemispherical candle-power as the practical basis of comparison of different sources of light. The committee, however, recognize that while this constitutes the best simple basis of comparison, a too rigid reliance on this method alone might, in certain practical cases, lead to misconceptions, and therefore regard the polar curve of light-distribution as the only really absolutely reliable guide in planning illumination; they also mention a series of methods by the aid of which such curves may be obtained experimentally. A list of the references to these researches is to be found in the detailed report in the *Journal für Gasbeleuchtung* (June 20th, 1908), and they are also described and reviewed in Liebenthal's 'Praktische Photometrie.' It is also advised that a factor connecting the values of the mean spherical and mean lower hemispherical candle-power should be given.

The value of the Ulbricht globe for determining the mean spherical candle-power of gaslights is also discussed, and it is pointed out that care must be exercised in its application to the measurement of light from inverted mantles which are known to be so sensitive to any interference with the air supply.

The commission, however, propose to carry out further tests on the effect of enclosing combustible sources of light within the Ulbricht globe, and to study the application of the globe to the general testing of gas lights.

In calling attention to the confusion that is created by the loose use of terms denoting the intensity of the light in different directions, the mean spherical and hemispherical candle, &c., the report repeats the symbols specially devised by the International Photometrical Commission at Zürich last year (see *Illuminating Engineer*, January, 1908, p. 78).

Some interesting discussion also took place with reference to the photometric testing of different qualities of illuminating gas, mixtures of coal gas and water gas, &c. The question of the effect of burning enriched gas with mantles was also brought up, especially with regard to the regulation of the air-supply.

Some details are also given of the results of experiments on the effect of transmitting gas at high-pressure from Lübeck to Travemünde.

The results suggest that the illuminating and calorific power was, as a rule, but slightly affected in the process. The decrease was however more marked in winter, when cold temperatures prevail. It was also found that under the exceptional conditions involved in long distance transmission, the accepted formulæ governing the size of main and quantity of gas transmitted do not rigidly apply.

The experiments, however, are to be extended with the object of clearing up certain apparently contradictory results.

A grant of 900 marks was voted to the Committee for the continuation of these and other researches during the following year.

Tests of High and Low Pressure Incandescent Gas Lighting.

By J. T. Morris, M.I.E.E.,

Professor of Electrical Engineering at the East London College.

During the preparation of material for a discussion on Gas *v.* Electricity, held by the engineering societies of the East London College, the supporters of the two sides were in search of reliable up-to-date figures of the efficiencies of the two kinds of illuminants. Having found considerable difficulty in obtaining such data, tests were instituted in the electrical engineering laboratories of an ordinary 3-light incandescent gas-burner, high pressure gas lamps, and a number of electric arcs of the most recent type.

It is the object of the present article to summarize and discuss the tests made with gas, reserving for a future communication those obtained with electric flame arc-lamps.

Tests on a 3-light incandescent gas lamp.

The form of lamp tested was of the type which is commonly adopted for lighting the outsides of shops. It had a clear glass enclosure, and consumed about 16 cubic feet of gas per hour, requiring for satisfactory working a pressure of some 3½ in. of water. It should be clearly understood that this lamp was not adjusted by an expert to give the best possible results. The author is convinced, however, from a fair experience of incandescent gas lamps, that during the photometric tests it was certainly not below the average of such lamps in the illumination it gave. During the 2½ hours that the lamp was burning the gas pressure from the street supply varied between the limits of 2·9 and 4·0 inches of water; while under test, however, the pressure at the lamp itself varied from 3·5 to 3·8 in. of water. The mean gas consumption was 16·1 cubic feet per hour. The lamp, as in all succeeding tests made at this College which are described here, was hung with the centre of the light-giving portion of the lamp on a level with the photometer, and the direct light of the lamp itself was screened from the photometer. By the help of two oval-shaped plane mirrors two beams were picked out on opposite sides of the lamp, and the combined beam was caught on another larger rectangular mirror, and so reflected into the photometer. The coefficient of absorption of this system of mirrors, determined on various occasions, was found to approximate closely to 30 per cent, that is, each mirror at an angle of 45 degrees reflects 84 per cent of the light which it receives.

In order to obtain the polar diagrams for these lamps it was merely necessary to shift the two oval mirrors into various positions, and then photometer the combined beam. The advantage, as is generally known, of this method is that it obviates the necessity for moving the lamp at all during test. The polar diagram is shown in Fig. 1, and the results are given in Table I. It should be mentioned that a 16 candle-power carbon filament lamp was used as a working standard. The photometer was either a Bunsen grease-spot or a Wild flicker.

Test on a High-Pressure Gas-Lamp.

Considerable progress has been made in recent years in the use of high-pressure gas in connexion with mantles. The Keith light of Messrs. Keith & Blackman was selected for the purposes of these tests, as a typical example of the latest practice. The author desires here to record his thanks to Mr. George Keith for the loan of apparatus and the facilities he placed at his disposal, and also to Mr. Chapman, of the same firm, for his

kind assistance throughout these tests.

The form of lamp tested was a nominal 1,500 candle-power inverted "arc-lamp" having a single mantle. Gas was supplied to the lamp at a pressure of 4 in. of mercury by means of a special rotary pump.*

The mantle is some 7 or 8 in. in length before insertion in the lamp, and is of a woven texture and very flexible. It is attached to a fire-clay collar having a screw thread. When screwed on to the nipple of the lamp, before any gas is turned on, it is ignited by a match, and it then shrinks to an irregular shape about 5 in. in length. The by-pass of the lamp is then lighted, and the gas pressure carefully turned on, with the result that the mantle now fills out with the pressure to a diameter of about $1\frac{3}{4}$ in. near the bottom, $1\frac{5}{8}$ in. near the top, and $3\frac{3}{4}$ in. in length. Thus there is about 18 sq. in. of mantle. The lamp has two clear glass enclosures.

Tests were carried out at a pressure of 4 in. of mercury, that is $54\frac{1}{2}$ in. of water. Polar diagrams of two tests made on different days are given in Fig. 2, and the numerical results are collected in Table I.; it will there be noticed how great an increase in the candle-power of the lamp results from quite a moderate increase in the calorific power of the gas.

In Fig. 3 is shown the result of a few tests made with the object of determining the effect of variation of pressure on the candle-power of the lamp. It will be seen that the lamp is not at all sensitive to these fluctuations of pressure. Thus a 1 per cent. change of pressure produces only half a per cent change in candle-power—a result very different from the magnitude of those produced in electric glow-lamps by pressure changes.

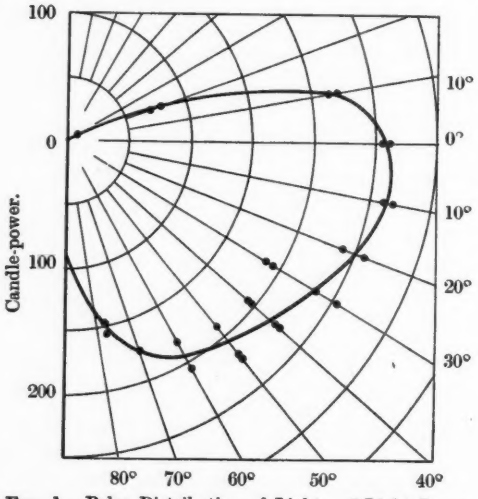


FIG. 1.—Polar Distribution of Light. 3-Light Incandescent Gas Lamp, with Shade, and Clear Globe.

NOTES ON GAS PHOTOMETRY.

Attention should be drawn to the fact that it is only with great difficulty that a 10 candle-power pentane lamp can be used with precision as a standard for determining the c.-p. of such high power incandescent gas-lamps as these, owing partly to the vast difference in the c.-p. of the lights under comparison, and also to the fact of the considerable colour difference of the two sources.

* Other tests of these lamps are described in the June number of this journal, on pp. 476 to 478, in the article by Mr. W. R. Herring on Gas Lighting at the Edinburgh Exhibition.'

The author has found a "sun" tantalum lamp to be well suited for use as a working standard, provided, of course, a reasonably steady source of electric current is available.

Further, the mode of expressing the candle-power of gas-lamps leaves a great deal to be desired. Apparently a not uncommon way of expressing the efficiency of such lamps is to pick out the maximum beam, and divide the candle-power of this beam by the cubic feet of gas consumed per hour, the result being given as a measure of the efficiency.

This, however, is open to the obvious objection that if any focussing reflectors were used it would be possible to force this figure up by several hundred per cent. The results are therefore given, as is customary in arc-lamp work, in mean spherical—and mean hemispherical—candle-power as well as in terms of the maximum candle-power.

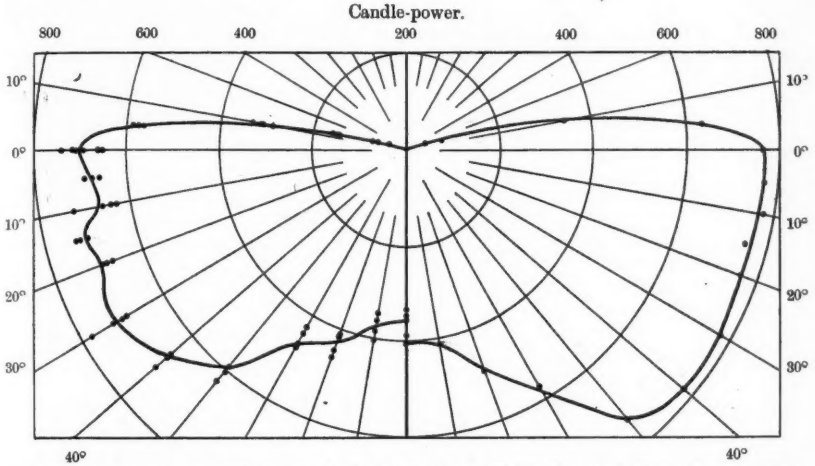


FIG. 2.—Polar curve of distribution of Light of Single Keith Inverted Incandescent High-Pressure Gas Lamp, having a double clear glass enclosure. Two tests. Shade in position.

NEED FOR CONTROL OF CALORIFIC POWER OF GAS.

Another matter deserving of attention is the constancy of pressure of the gas supply. Especially is this necessary for some types of ordinary incandescent gas-burner. Many of these are very sensitive to pressure fluctuations. It is frequently true, however, in house lighting that these changes of pressure are due more to the use of too small piping in the house itself than to external variations of pressure.

But a matter of far greater moment, and one the importance of which the author wishes strongly to emphasize, is the urgent need which exists for the supply of gas of a minimum value of *heat energy* for a given price; and not, as at present is the case, for the supply of a nearly definite volume of gas for this price, trusting to the off-

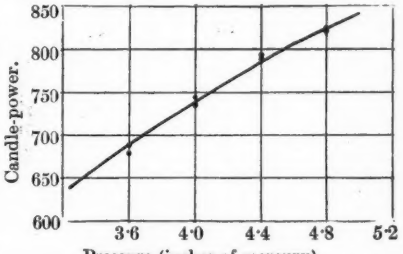


FIG. 3.—Curve showing relation of Candle-power to gas pressure for Keith Light.

chance that this volume is capable of yielding a proportionate supply of heat.

The author is aware that at the present time tests are daily made in

the gas-testing stations in London of the calorific power of the gas,* with the object of possible *future* legislation. But gas is so largely used for illuminating purposes (by the medium of heated mantles), for heating, for cooking, and for power, that surely the time has already come when the *calorific power* of gas should be the *most important factor* in determining the price paid per cubic foot. Possibly mere volume might again become of greater importance in the event of airships and balloons becoming a recognized means of transit!

However this may be, the inequity of the present system of charging by volume is well illustrated by the results obtained with the Keith lamp previously referred to. It is supplied by the manufacturers with the object of giving a specified candle-power for a given rate of consumption of gas. What do we find it does in actual practice? The above tests show that the maximum candle-power of the lamp is in one part of London about 800 candles; take it to another part of this city, and it yields 1,250 candles; and take it to Edinburgh, when it would probably yield some 1,500 candles! Truly a most disconcerting state of affairs for the much-tried incandescent gas lamp manufacturer!

TABLE I.

Date.	Name of Lamp.	Globe.	Mean Spherical Candle-power.	Mean Hemispherical Candle-power.	Maximum Candle-power.	Angle below horizontal at which maximum Candle-power occurs.	Gas consumption in cubic feet per hour.	Gross calorific power of Gas.	Mean Spherical Candle-power per cubic foot per hour.	Mean Hemispherical Candle-power per cubic foot per hour.	Maximum Candle-power per cubic foot per hour.
19/5/08	Ordinary 3 burner Incandescent Gas	Clear	125·	225·	250·	10°	16·1	480· about	7·8	14·0	15·5
5/6/08	Keith Light	Double clear	380·	640·	720·	0° to 30°	23·3	—	16·3	27·5	30·9
6/6/08	—	—	425·	720·	780·	0° to 40°	22·8	—	18·6	31·6	34·0
11/6/08*	—	—	680·	1140·	1250·	0° to 40°	23·8	545·	28·6	48·0	52·5

* This test was made at Messrs. Keith & Blackman's Works, which are supplied by a different gas company. The apparatus used, however, was standardized in the Electrical Engineering Laboratories of the East London College.

* See article on 'Gas Testing in London,' by Mr. R. A. Dibdin, in this journal, May, 1908, p 390.

The Mercury-Carbon Glow-Lamp.

By B. Duschnitz.

In the year 1900 Sinding-Larsen, of Frederiksvaern in Norway, obtained a German patent (No. 114,438) for an entirely new variety of glow-lamp, in which the glass bulb was filled with suitable gases and vapours under high pressure.

Now when a glow-lamp receives a current considerably in excess of that for which it was intended, its efficiency is increased, the increase in intensity so occasioned being proportional to the fifth power of the temperature of incandescence of the filament. The melting-point of the material of metallic filaments sets a limit to this method of increasing efficiency. In the case of carbon-filament lamps this difficulty does not arise, but here again a new limit is set by the increased tendency to volatilization of the carbon.

Alf. Sinding-Larsen, however, found that this increased tendency to volatilize could be restricted by considerably increasing the pressure of gases within the bulb of the lamp. For this purpose he utilized mercury-vapour, which has both the desirable chemical and physical inertia, not being absorbed by a carbon filament, and not exerting any chemical action upon it. The object of Sinding-Larsen was to compress the molecules of the glowing carbon, and thus to hinder the projection of particles from its incandescent surface. But naturally, as he discovered, this desired effect cannot be produced if the inert gas is allowed to penetrate into the interior of the filament.

In order to avoid the possibility of a short circuit such as might easily arise in the case of a bulb of the ordinary shape, an exhausted glass tube in the form of a U was utilized in the Sinding-Larsen lamp. A small globule of mercury contained in this tube was caused gradually to evaporate by the heat of the filament and the necessary high pressure of the inert atmosphere was produced by this means.

Nevertheless, Sinding-Larsen does not appear to have made very great progress with his invention, the patent for which was allowed to expire in 1903. Subsequently Fritz Dannert took out a German patent (No. 166,372 of 1904), on very similar lines. He noticed that when the device shown in Fig. 1, in which a U-tube is filled up to the level *d* with mercury, the latter tended to creep up each side of the tube until the level *e* was reached, when an explosion occurred, owing to the mercury spurting against the filament.

When a smaller quantity of mercury is used the mercury, even in the case of alternating current lamps, tends to collect at one pole. According to Dannert, a serviceable and continuously working lamp was only possible when the mercury vapour or other vapour-creating substance was unable to travel from pole to pole by an appreciably shorter path than the filament itself. He also stated that the weight of body to be vaporized must not weigh down the filament. The conduction of heat from the filament to the vaporized material should take place in the following manner :—

The filament should never actually touch the surface of the mercury, but be kept a very small distance above it, and this distance should be maintained constant as the mercury warmed up, expanded, and began to volatilize owing to the heat generated. These conditions are exemplified in Fig. 2, where it will be seen the mercury globule, in the cold state, just fails to touch the filament.

Dannert, however, did not proceed much further than Sinding-Larsen,

for his patent was allowed to expire in the year 1906.

More recently, however, a lamp of this type has been developed with greater practical result, some hundreds being in actual use in Germany at the present time. The lamps burn at a consumption of 1·5–1·7 watts per H.K. —about the same as in the case of the Tantalum—with a life of 500–700 hours.

Being personally acquainted with the inventor of the new lamp, the writer is in a position to give some account of its progress, and the difficulties that have been overcome in its development. Some of these formed the basis of a recent paper read before the

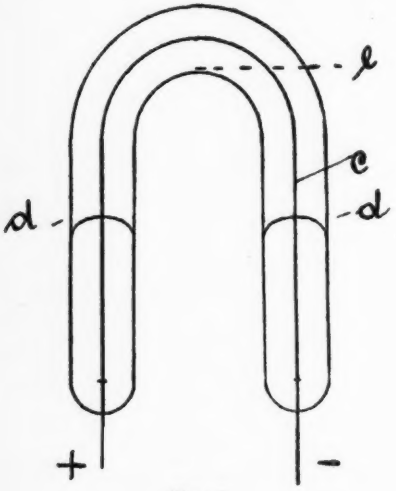


FIG. 1

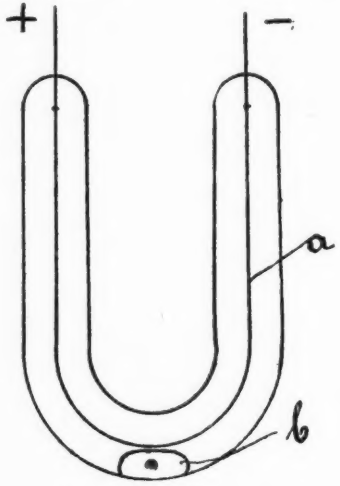


FIG. 2.

Elektrotechnischer Verein (May 26th, 1908). What follows, however, is based chiefly on the writer's personal experience and information furnished by the inventor, and the report of Dr. Lux of Berlin.

The German patent (No. 176,006) referring to this lamp was taken out by R. Hopfelt, of Schöneberg, near Berlin, According to this patent the previously employed U-tube arrangement was avoided, an ordinary glass bulb, in which the two leading-in wires are separated by a special glass diaphragm, being utilized. After the expiry of the Dannert patent, however, the inventor reverted to the U-tube device.

Hopfelt has found that the use of a U-tube does not alone suffice to secure the requisite conditions. It is desirable that the density of the vapour employed should be as high as possible, and in order to attain this result he finds it necessary to heat up the tube along its entire length; otherwise the vapour would condense on the cooler portions of the tube-surface. Since the sole source of heat that can conveniently be used is the glowing filament itself, it has also been found necessary to introduce an inert gas into the glass vessel. This principle first found practical application in patent No. 180,107, a gas being specified which is non-condensible and also capable of conducting the heat from the filament to the walls of the tube. Hopfelt states that the internal pressure in the lamp, in the cold state, must be exceedingly low; otherwise the mercury would volatilize with difficulty, owing to the expansion of the gas with the heat developed by the filament. In this lamp an ordinary carbon filament is employed, but under exceptional conditions. Owing to the greater cooling action of the surrounding nitrogen gas the temperature of the filament would

be lower than in the case of an ordinary glow-lamp receiving the same power when first lighted up. Afterwards, when the mercury has had time to volatilize, the conditions are changed.

Hopfelt demonstrated this by suddenly applying a small current to the lamp in its warmed-up state. Under these conditions the current necessary to just cause the filament to begin to glow was noted, and it was observed that whereas the ordinary lamp began to glow when it received 0·2 amperes and 17 volts, *i.e.*, 3·4 watts, the mercury lamp required 0·25 amperes and 21 volts, *i.e.* 5·2 watts—a difference of 55 per cent. When burning under normal conditions the mercury lamp received 36 per cent more power. The power given to a filament must therefore be somewhat increased in order to attain the same initial temperature, but the brightness of the light yielded by such a lamp is considerably greater when the lamp is burning in an atmosphere of mercury vapour under practical conditions. Hopfelt, for instance, found that an ordinary 65-volt glow-lamp, not utilizing mercury, consumed 0·87 amperes and yielded 16 H.K. The same filament, however, when running in an atmosphere of mercury vapour to which was added a small quantity of nitrogen, consumed 76·5 volts and 1·02 amperes, and yielded 48 H.K.—*i.e.*, 1·625 watts per H.K. as compared with 5·534 in the first instance. According to Dr. Lux's experiments this is to be ascribed to the fact that the filament is then at a *higher* temperature than would be the case in vacuo. This point is referred to later on.

In the manufacture of these lamps Hopfelt does not proceed to complete exhaustion, but only until an internal pressure of 0·3 to 2 mm. of mercury is obtained. During the initial burning of the lamp a portion of the mercury vapour combines with the oxygen of the air remaining in the bulb, a small quantity of nitrogen being thus left behind.

In Fig. 3 is shown a special form of the Hopfelt lamp.

The U-shaped tube *r* contains the carbon filament *f* and the drop of mercury Hg. The actual lamp is surrounded by the outer bulb *b* and is attached to the cap S. In this case the filament is supported in four places at *a*, *a*, *a*, *a*; this, however, is only necessary in the case of high pressures, such as 220 volts. Lamps intended for 120 volts do not require any such supports.

Hopfelt submitted his lamps to the laboratory of Dr. Lux of Berlin, in order to solve the following questions:

1. What is the exact effect of the drop of mercury enclosed within the bulb upon the candle-power and efficiency of the lamp?
2. What is the exact explanation of the increase in the amount of light obtainable from an ordinary carbon filament?
3. How do the output of light and efficiency of a lamp change during its life?

Dr. Lux soon found that the behaviour of the lamp was quite different according as the lamp was hung vertically from the cap, or burned in a vertical upright position, the cap being at the base of the lamp, the drop of mercury being situated in the hottest or coldest regions of the tube respectively. If burnt in the latter position, the mercury does not readily volatilize, and the lamp behaves very similarly to an ordinary carbon filament lamp, burning, however, at a consumption of 2 to 3 watts per H.K. But when the lamp is inverted the drop of mercury is brought into the immediate neighbourhood of the hot filament, and soon begins to evaporate, and to recondense in the colder regions of the tube.

The lamp reaches a steady state in about five to ten minutes, the carbon filament then glowing in an atmosphere of mercury vapour. The intensity of the light is simultaneously increased and the consumption of power sinks to 1·5 to 1·7 watts per H.K. (horizontal).

Dr. Lux made a considerable number of photometrical observations of the light of these lamps, some of which are given in Table I.

It has been supposed that the greater efficiency of the Hopfelt lamp was attributable to the luminescence

of the mercury vapour, and that the lamp thus formed a combination of the ordinary carbon and mercury vapour lamps. Dr. Lux, however, has remarked that if the vapour contributed any marked luminescence to the total light effect of the lamp, the characteristic line-spectrum of luminescent mercury vapour would be visible. Yet careful investigations of the spectrum, carried out with a spectroscope of great dispersive power, revealed no

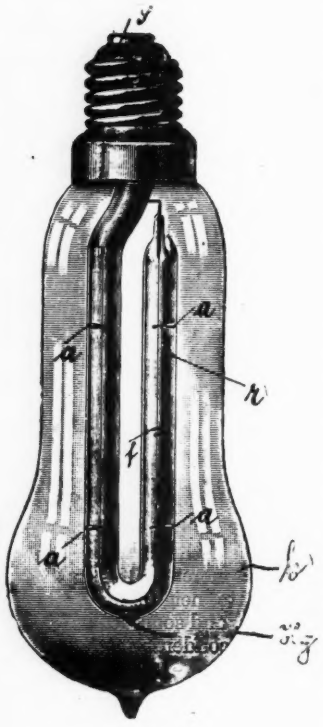


FIG. 3.

such lines. On the contrary, only a continuous spectrum, similar to that yielded by an incandescent solid, was observed.

Dr. Lux had also considered the possibility that the mercury vapour spectrum might have been masked by the considerably brighter continuous spectrum due to the filament. But this suggestion was proved to be incorrect by tipping the lamp so that a little of the mercury came in contact with one or other of the leading-in conductors. When this happened the lines appeared for the moment quite distinctly visible against the background of the continuous spectrum, only to vanish when this globule of mercury had evaporated.

Moreover, no dark *absorption lines*, due to the presence of mercury vapour, were ever discernible, as might have been expected. It is therefore legitimate to conclude that the mercury vapour in the tube does not luminesce, though it is still possible that the mercury vapour gives out light by being carried up to the temperature of incandescence. When actually looking at the lamp one observes a filament about 0·3 mm. in diameter, apparently surrounded by a luminous haze about 5 mm. in diameter. It must also be stated that the light from the Hopfelt lamp appears to the eye white, like that from the metallic filaments. Finally, the relatively small value of the current—about 0·7 amperes would not seem sufficient to cause any regular ionization of the mercury vapour, ionization being known to require a current of the order of 2 amperes.

On these grounds Dr. Lux comes to the conclusion that the mercury vapour does not contribute *directly* to the increased output of light, and explains its indirect action on the assumption that it forms a warm jacket round the filament, and so reduces its rate of radiation. As a result the temperature of the filament is increased, and, when it is remembered that the light is proportional to the *fifth power* of the temperature of incandescence, it will readily be understood that a relatively small increase in temperature may considerably increase the candle-power of the lamp.

In order to study this question Lux determined the temperature of the filament, both when surrounded by mercury vapour and when burning under ordinary conditions. By bolometric measurements the ratio of the light-energy to the total radiation from the filament were determined in the two cases.

When the Hopfelt lamp was supported by the cap in an upright position, so that no mercury vapour was created, the total radiation received upon a bolometric surface 1 sq. mm. in area and 1 metre distant from the lamp, proved to be $4{\cdot}02 \times 10^{-4}$ watts, while the light energy radiated under the same circumstances was $0{\cdot}13 \times 10^{-4}$ watts. The radiant efficiency was therefore about 3·2 per cent.

When, however, the lamp was inverted so that the influence of the mercury vapour came into play, the total radiation, and light-energy radiated were $4{\cdot}75 \times 10^{-4}$ watts and $0{\cdot}18 \times 10^{-4}$ watts respectively. The radiant efficiency in this case thus worked out to 3·72 per cent.

This increase in efficiency might be easily explained by an increase in the temperature of incandescence of the filament, and hence a shifting of the maximum of the curve of energy radiation nearer the visible range of the spectrum.

The direct determination of the absolute temperature of the filament was carried out by Dr. Lux with a spectrophotometer calibrated by observations of a "black body.' By this means the "black body" temperature of the lamp in its upright position was determined as 2155° (absolute), and in its hanging position 2260° (absolute). The corresponding values of the light-intensity were 35 and 43·8 H.K., and this is in fair accordance with the theoretical result that :—

$$\frac{(2155)^5}{(2260)^5} \text{ should equal } \frac{35}{43{\cdot}8}$$

We are therefore led to suppose that the increased intensity of the Hopfelt lamp is simply a consequence of its higher absolute temperature.

In Table II. are shown the performances of a few sample experimental lamps as determined by Dr. Lux.

From these results it will be seen that the consumption of these lamps averaged about 1·7 watts per H.K., and that this consumption remained practically constant throughout the period of the tests. The efficiency of the Hopfelt lamp, as at present manufactured, is thus lower than that of the Osram, and about the same as that of the Tantalum lamp. The inventor, however, is not without hopes of obtaining yet more favourable results. He showed the writer of this article several lamps which burnt at about 0·5 watts per H.K., but admitted that the life of such efficient lamps would be at present only a few hours. On the other hand, an ordinary carbon filament, burned under these conditions, would probably give way in the course of minutes, while metallic filaments similar to those utilized in the tungsten lamps would melt outright. Meanwhile, Hopfelt hopes, with well-prepared carbon filaments, to produce lamps consuming only 1 watt per H.K. and with a life of 600 hours.

It may be inquired whether metallic filaments might not be advantageously employed in the Hopfelt lamp. The fact that these filaments melt at really high temperatures is, however, a disadvantage. Moreover, ionization might be set up between the neighbouring portions of a folded metallic filament, while a filament coiled into

TABLE I.

Lamp No.	P.D. Volts.	Current Amps.	Power Watts.	Lamp supported vertically upright.		Lamp hanging vertically.	
				Intensity (H.K.)	Power Consumption per H.K.	Intensity H.K.	Power Consumption per H.K.
					Watts per H.K.		Watts per H.K.
1	125	0·65	80·25	27·5 H.K.	2·9	60·0 H.K.	1·34
2	110	0·60	66·0	27·1 ,,	2·5	41·2 ,,	1·6
3	110	0·61	67·10	27·0 ,,	2·5	42·2 ,,	1·6
4	110	0·66	72·60	35·1 ,,	2·1	48·9 ,,	1·5
5	220	0·47	103·40	35·4 ,,	3·1	64·0 ,,	1·6
6	220	0·48	105·60	37·7 ,,	2·8	69.0 ,,	1·5

the U-tube form would necessitate a tube at least three times as long as that employed with a corresponding carbon one.

Also, although the mercury may rebound quite 5 cms from the wall of the tube when the lamp is briskly shaken, the elastic carbon filament is not broken thereby. This refers to the 120 volt unsupported filaments; the writer has observed that the supported high-pressure filaments can be broken by very violent shaking, owing to the fact that the natural period of the filament is shortened so that it cannot give way to the impact of the agitated drops of mercury. But if metallic filaments, with the exception of the tantalum, were subjected to vibration of this nature they would, of course, be immediately destroyed.

TABLE II.

Lamp.	Volts.	Watts.	Intensity (H.K.)	Watts per H.K.	Burning hours.
a	110	64·9	32·2	2·02	0 hours
	110	64·9	27·6	2·35	50 ,,
b	110	63·8	30·8	2·06	0 ,,
	110	64·9	30·9	2·13	58 ,,
c	110	62·7	31·7	2·03	0 ,,
	110	67·5	36·0	1·87	58 ,,
d	110	70·4	39·9	1·76	0 ,,
	110	71·5	34·4	1·82	120 ,,
e	110	73·2	46·2	1·58	0 ,,
	110	73·2	46·3	1·58	120 ,,
f	110	70·95	39·5	1·79	0 ,,
	110	72·05	45	1·61	48 ,,
g	110	70·8	42	1·68	0 ,,
	110	68·7	41·6	1·65	48 ,,
h	110	70·4	43·6	1·61	0 ,,
	110	71·5	44·1	1·62	48 ,,
i	220	101·2	59·5	1·70	0 ,,
	220	97·8	47	2·08	95 ,,
k	220	103·95	64	1·62	0 ,,
	220	103·5	64	1·62	40 ,,

Incandescent Glow-Lamps for Signalling Purposes.

GLOW-LAMPS have already often been utilized for signalling purposes, and there are always new possibilities opening out for their use in different directions. One such example is furnished by the new electric signs used on the underground railway to indicate the order of arrival of the next few trains.

Another more familiar example, of course, is the use of small glow-lamps in the telephone exchange.

Other very ingenious applications of the same principle occur in certain American hotels. Glow-lamps fixed in the manager's office must be turned on by employees working on a particular floor by switches in that region, so that the manager has a complete check of the whereabouts of all his staff, and can find any one at any minute should he or she be wanted.

In methods of signalling involving the rapid turning on and off of lamps, the metallic filament glow-lamps are at a certain advantage, because the filaments become heated and cool so much more quickly.

The Lighting of Pictures and Picture Galleries.

By G. A. T. Middleton, A.R.I.B.A.

The very important problem of the illumination of works of art, pictures, and picture galleries is one that presents peculiar difficulties and demands very careful consideration. Works of art are created primarily for the gratification of the eye, and it is only reasonable to expect that unique pictures, &c., which are purchased at considerable cost for the benefit of the nation, should afterwards be exhibited under the very best conditions, and illuminated in such a way as to render it a pleasure to look at them.

At present the possibility of extending artificial lighting to such galleries has, perhaps, hardly been sufficiently considered. There are many people interested in art who are rarely free to indulge their taste in the daytime, but would doubtless be glad to study pictures in the evening, if only adequate artificial illumination were provided. Moreover, any one who has had experience of designing facilities for daylight illumination knows how difficult it is to ensure sufficient lighting at all parts of a big building and under varying atmospheric conditions, and on dull days the illumination in certain regions of many of our picture galleries will not unfrequently be found to be quite insufficient to do justice to the pictures exhibited.

Theoretically, artificial light, being under control, ought to enable the artist to secure special effects that he otherwise could not hope to attain. As a rule the appearance of a picture under artificial light is very different from that in the daytime. Many a picture which appears commonplace and dull in the daytime is rendered attractive by artificial lighting, while conversely a picture which is brilliantly effective by daylight often becomes vulgar and obtrusive when illuminated artificially. It is therefore necessary to consider the question scientifically, and to study the object which the artist had in view.

A painter is not bound by conventional rules nor practical considerations, and if, for the sake of composition, a shadow looks best when projected towards the light, so it will very probably be found. Architectural draughtsmen are even greater sinners in this respect than painters, as careful examination of their perspective drawings at the Academy or any other exhibition will show.

When artists attempt to depict artificial light and its effects they invariably treat of located lights, which they employ much as the stage manager of a theatre does his limelight. Their effort is to bring into prominence some particular part of their composition while throwing the rest into shadow. Startling effects are often thus created, and many an interior, if carefully analyzed, will be found to owe much of its effect to methods of lighting which are absolutely impossible in practice.

But when it comes to the actual lighting of pictures hung in a room or gallery the artist's ideal changes. He will probably demand a generally diffused illumination, rather than a centralized light, even though there are many cases in which the latter would be considered preferable from an artistic point of view. In so deciding he is guided by the fact that, unless such a system is adopted, it is almost impossible to avoid reflection of the sources of light off the surface of the picture. In the New Gallery, the Academy, and many others, clusters of incandescent lamps are so placed as to give an effect approximating to that obtained by the admission of daylight through glass skylights. It need hardly be said that it is absolutely essential in a picture gallery to prevent the possibility of the sources of light being so placed as to be troublesome to the eye, in order that the visitor may have nothing to distract him or interfere with his comfort.

In our national collections no arti-

ficial illumination at all is used at present, although the reason for this is probably to be found in the deterioration of paintings when exposed to the fumes of combustion emitted by certain illuminants, and also the serious consequences of a fire, rather than in the mere mechanical difficulties involved. At the present time there may be said to be a number of methods by which an approximately uniformly diffused artificial illumination may be obtained. We may, for instance, imitate daylight conditions by suitably grouping our sources of light above diffusing glass roofs, or we may utilize inverted lamps and reflection off a white ceiling. The new Moore vapour tube lamp (see *Illuminating Engineer*, January, 1908) is also said to provide both a very soft and uniform illumination, combined with good colour definition.

On the other hand there are often pictures which require special local lighting by concealed lights in order to show to the best advantage, and one would imagine that the intensity of illumination desirable under these circumstances would depend very greatly upon the nature of the picture. The method adopted in the case of the portraits of past presidents in the meeting room of the Royal Institute of British Architects is an excellent example of this type of lighting.

One question, however, which goes to the very root of picture gallery illumination is that of correct revealing of colour—by "correctness" being generally understood their appearance in diffused daylight. As a rule pictures are painted with the object of being exhibited in daylight, and when their charm depends upon the assembling of harmonious and delicate shades of colour, it will readily be understood that the distorting effect of some artificial illuminants is often anything but pleasant. At the present time there cannot be said to be any general and definite agreement as to which of the existing sources of light most closely resembles daylight, although the enclosed arc lamp, acetylene, the carbon dioxide Moore light, and other illuminants, have all been claimed to be advantageous in this respect.

But perhaps the most important qualities which must be exacted from an illuminant for picture galleries are those affecting the wellbeing and safety of the often priceless and unique pictures exhibited.

The possibility of fire must be reduced to a minimum. An objection that has been urged against gas-lighting is that the products of combustion may gradually affect the pictures. Certainly electricity is free from this suspicion; yet if adequate provision is made for ventilation, including means of carrying away the injurious gases *immediately* they are created, it is probable that gas can be used without serious risk. It is true that gas-lighting has, in several instances in the past, proved to be injurious both to oil and water-colours, but in these cases the lighting was carried out by the old flat-flame burners, and without adequate ventilation. Probably the best plan of all, if gas is used, is to keep the lamp entirely outside the enclosure containing the pictures—to place it outside and above a diffusing skylight, for instance.

There are also many country houses where collections of valuable pictures have been gathered together, and in many such cases neither gas nor electricity is available. Under these conditions, either a small electrical plant will be installed or recourse will be had to self-contained systems of lighting, such as acetylene or petrol-air gas. Here again questions of ventilation and security from fire must be given careful consideration.

When we bear in mind the desirability of keeping historic paintings intact for centuries without their fading or losing their attractive appearance in any way, we can readily understand how small and almost inappreciable changes may gradually take place and eventually cause great mischief. In this connexion the possibility of certain kinds of light causing the colours of pictures to fade must not be lost sight of. It has been proved, for instance, that ultra-violet light is particularly effective in this way, and we should

therefore avoid sources of light rich in such rays, or at least take precautions to render them innocuous. It is, of course, also possible that even visible rays exert the same influence to some degree. This is therefore one other aspect of the question on which further information is required, before we can definitely decide on the best variety of illumination for use in picture galleries.

The Illumination of the Galerie Heinemann, Munich.

In the above article Mr. Middleton has emphasized the value of diffused illumination in picture galleries. The mann Picture Gallery at Munich by screened "Regina" arc lamps. We understand that this system of illu-



illustration shown below, representing one method of achieving this result, may therefore be of interest. It represents the lighting of the Heine- mination was specially selected with the object of representing the colours as correctly as possible.

The Production and Utilization of Light.

Luminous Efficiency and the Mechanical Equivalent of Light.

By Dr. C. V. Drysdale.

(*Continued from p.* 546.)

In order to find the amount of heat lost by convection a calorimeter was made (Fig. 11), having a hollow conical bottom and a long spiral worm extending to the top, the base being blackened. This was suspended over the lamp under test so that the convection currents would collect in the cone as shown, and heat the calorimeter in their progress along the worm. If then R is the total radiation, and C the convection from the lamp, we have :—

$$R + C = 4{\cdot}18\ W$$

$\frac{\Omega}{4\pi} R + C = \omega \frac{\delta\theta}{\delta t}$ where Ω is the solid angle which the base of the calorimeter subtends at the lamp : ω the total water value of the calorimeter, and $\frac{\delta\theta}{\delta t}$ the rate of rise of temperaure. Tests made in this way appeared to show that the convection loss was not more than 2 or 3 per cent of the total power, and could be neglected in view of the accuracy which could be obtained. Conduction was reduced by having long, heavily insulated leads to the lamp, and was neglected.

The method of forming the spectrum requires a little consideration. As we are not making measurements upon the source A, any absorption in the spectrum-forming devices is of little importance. We have, however, the possibility of anomalous dispersion in a prism or of overlapping spectra with a grating. It has been shown by Nichols that carbon bisulphide, besides being remarkably diathermanous, obeys Cauchy's dispersion formula as far as $\lambda = 2\mu$ or more, and that moreover since its refractive index is closely equal to the square root of its specific inductive capacity, there is no reason to suspect any serious departures from this law in the longer wave lengths. On this account probably the best means of forming the spectrum is by a bisulphide prism, though it would be more satisfactory to have determinations with gratings as well.

The greater number of the observations were made in the yellow-green which was judged by eye to be in the neighbourhood $\lambda = {\cdot}54\mu$ proposed by Guilleaume. Having regard to the fact that the mounting hardly justified accurate determinations of wave length, that the point $\lambda = {\cdot}54\mu$ can hardly be said to have been definitely determined as the point of maximum efficiency, that in the region of maximum efficiency the variation would not probably be great, as was confirmed by test, and lastly, that in order to avoid trouble owing to the Purkinge effect it was considered advisable to work at illuminations not exceeding two or three candle-feet, in which case the bolometer sensitiveness was not very great, it was considered superfluous to determine the wave length with greater accuracy. It may be said that the sensitiveness of the arrangement seemed to allow of the definite detection of half a watt at a distance of about 2 metres.

In making determinations on white light the slit was broadened considerably, and by covering it up from each side successively it could be adjusted so that light passing one edge of the slit gave a very dark red light on the photometer screen, while that from the other edge gave a deep violet light on it. In this case the result produced

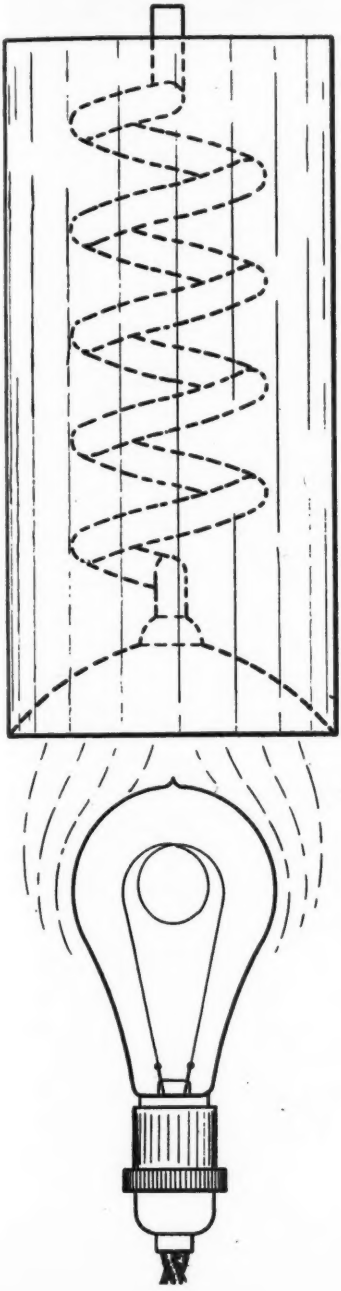


FIG. 11.

by the whole slit was of a pure white light from which all the invisible radiation was cut off.

A number of preliminary observations were taken with arc and Nernst lamps as sources of light, and reversing the photometer box, &c. Considerable trouble was, however, found with drifting of the galvanometer, and this was traced to the presence of the observer. The mean result, however, from 24 observations was ·08 watt per c.-p. After this the whole of the apparatus was removed, the photometer bench, sliding screen, &c., being set up in a dark room through the wall of which an aperture was made for the projection of the spectrum, and a second small aperture for the observation of the photometer. In this way the whole of the observations could be taken without entering the room, and the readings were much more satisfactory.

In Table II. are given the results which were taken in this manner. The observations extended over several days, and changes were made in the intensity of the beam, position of standard, &c., so as to eliminate as far as possible any constant source of error.

The most noticeable feature of the results in Table III. is the progressive decline in the value of the mechanical equivalent. This is due in part to the increasing care which has been taken by observers in defining the limits of the radiation, and also probably to the fact that some of the later values have been take on sources at a higher temperature, in which the dominant wave-length more nearly approached the most efficient value. It is worthy of note that the results obtained in the present investigation for white light from the Nernst lamp agree very approximately with the value given by Angström, while those taken with the arc give a somewhat lower value. The further reduction of the equivalent for the monochromatic source is, of course, what would be expected; in fact, one would rather perhaps have anticipated a lower value, in view of the great inefficiency of the red end of the spectrum. It should be mentioned

that during the preliminary observations a few values were successively obtained on one occasion as low as those given by Russner, but there were many disturbing elem nts present. The value of ·06 for the mechanical equivalent found by us may probably be accepted as a fairly close one, although small sources of error such as convection, scattering, &c., if eliminated, would tend to reduce the value. It would appear of great importance that the investigation should be repeated, using exactly the same method, but with more refined apparatus, and the writer hopes to be able to do this shortly. In the meantime, however, we may conclude that an ideal source of white light should give us at least 10 candles per watt, while if monochromatic, nearly 17 candles per watt should be obtained. At the present time, therefore, the carbon filament glow-lamp, taking 4 watts per candle, has an efficiency of about 2·5 per cent in terms of the ideal white light, or about 1·5 per cent as compared with the monochromatic

TABLE II.—OBSERVATIONS ON THE MECHANICAL EQUIVALENT OF LIGHT.

(a) *Light approximately monochromatic, yellow green.*

Standard Lamp.		Comparison Lamp.				Mechanical Equivalent.
Distance. d.	Candle Power. K.	Distance. D.	Current. Amps.	P.D. Volts.	Watts. W.	$M=\frac{W}{\cdot 78K}\left(\frac{d}{D}\right)^2$
80	24·5	116·7	·145	31·8	4·61	·0555
80	24·5	166·7	·13	29·0	3·77	·0455
70·6	24·5	165·5	·15	32·6	4·9	·0468
78·0	20·6	165·5	·145	31·8	4·48	·0620
78·0	20·6	165·5	·16	34·5	5·52	·0765
78·0	24·5	165·5	·17	36·2	6·15	·0715
85·0	24·5	165·5	·15	32·4	4·85	·0670
76·3	24·5	165·5	·155	33·2	5·15	·0573
76·3	20·6	165·5	·145	31·6	4·58	·0605
76·3	24·5	165·5	·15	32·2	4·83	·0536
57·4	24·5	165·5	·23	45	9·9	·0622
121	24·5	165·5	·095	32·2	2·11	·0590
					Mean.	·0598

(b) *White Light from Wide Slit.*

Standard Lamp.		Comparison Lamp.				Mechanical Equivalent.	
Distance. d.	Candle Power. K.	Distance. D.	Current. Amps.	P.D. Volts.	Watts. W.	$M=\frac{W}{\cdot 78K}\left(\frac{d}{D}\right)^2$	
149	16·0	206	·115	26·3	3·03	·127	Nernst filament
86	13·0	263	·225	47·0	16·6	·1115	Nernst filament
					Mean.	·1193	
76·1	16	263·5	·23	47·5	10·9	·073	Arc.
75·0	16	263·5	·25	50·5	12·6	·082	Arc.
89·6	24·5	166·5	·16	34·4	5·5	·0835	Arc.
89·6	24·5	166·5	·16	34·4	5·5	·0835	Arc.
					Mean.	·0805	

TABLE III.

Mechanical Equivalent of Light.

FROM OBSERVATIONS ON LUMINOUS EFFICIENCIES.

Source.	Mechanical Equivalent. (Watts per Hefner.)			
	E. Merritt.	J. Russner.	W. Wedding.	H. Lux.
Hefner Lamp				·108
Petroleum Lamp			·0289	·105
Alcohol Lamp			·001155	
Acetylene Flame				·103
Incandescent Gas Light			·00226	·037
Hydropressgaslicht, Lucas Light, Millenium light			·00715	
Carbon Filament Lamps	A. ·18	I. ·018	·0104	·085
,,	·252	II. ·020		
,,	·171			
,,	B. ·4405			
,,	C. ·274			
,,	D. ·324			
Nernst Lamp			·016	·073
Tantalum Lamp		·029		·080
Osmium Lamp		·035	·00967	
Osram Lamp		·033		·075
Arc Lamps, D.C.			·00161	·047
,, D.C. enclosed				·021
,, A.C.				·038
Flame Arc, yellow				·041
,, white				·031
Uviol Mercury Vapour				·015
Quartz Lamp				·014

MECHANICAL EQUIVALENT OF LIGHT.—COLLECTED VALUES.

Observer.	Date.	Method.	Source.	Unit.	Mechanical equivalent.			
					Calories per second.		Watts.	
					Per Hefner.	Per C.P.	Per Hefner.	Per C.P.
J. Thomsen...	1863	A.	Sperm candle	Sperm candle, 8·2 grammes per hour	0·065	0·0733	0·276	0·3075
	,,	,,	Moderator lamp...		0·0585	0·065	0·245	0·272
	,,	,,			0·0615	0·0683	0·257	0·286
	,,	,,	Gas flame.....		0·063	0·070	0·264	0·293
	,,	,,			0·0553	0·0615	0·232	0·258
O. Tumlirz and Krug	1888	A.	Incandescent platinum wire	Hefner	0·041	0·0455	0·1715	0·19
O. Tumlirz...	1889	A.	Hefner lamp.....	Hefner	0·0455	0·0505	0·191	0·212
K. Ångström	1903	C.	Hefner lamp.....	Hefner	0·0259	0·0288	0·1085	0·121
Writer and A.C. Jolley	1907	C.	Nernst filament ...	Candle	0·0256	0·0284	0·107	0·119
	,,	,,	Arc	,, ...	0·0173	0·0192	0·0725	0·0805
	,,	,,	Monochromatic, yellow-green.....	,, ...	0·01285	0·0143	0·0538	0·0598

Method A.—Thermopile and absorptive screens.

Method C.—Direct measurement of energy in spectrum.

In this table the Hefner has been taken as 0·90 C.P. See Paterson, 'Proc. Inst. E. E.,' vol. xxxviii. p. 286, and Fleming, p. 311.

source. The Tungsten lamp, which may be taken as having a power consumption of about 1·25 watts per candle has an efficiency of 8 per cent. in terms of white light, or of 5 per cent in comparison with the monochromatic source. It is hardly probable that very much better results than this will be obtained by incandescence methods, unless bodies can be found having a very selective emission.

In conclusion, it is of some interest to deduce from this result the amount of power required to stimulate the sensation of vision. If we take a candle at a distance of a kilometer this corresponds to an intensity of radiation of $\frac{6\times10^{5}}{4\pi\times10^{10}}=5\times10^{-6}$ ergs per sq. cm. per sec. approximately. Taking an equivalent pupillary diameter of 5 mm., or about ·19 sq. cm., this gives $9{\cdot}5\times10^{-7}$, or about one millionth of an erg per second, or 10^{-13} watts as the amount of power received by the retina. Similarly the amount of power per sq. cm. of an illuminated surface, required to render it visible, could be calculated. Drude* states that a star of the sixth magnitude is equivalent to a Hefner at a distance of 11 k.m. This gives $\cdot7\times10^{-8}$ ergs per second as the minimum stimulus for vision.

* 'Theory of Optics,' p. 486.

(*To be continued*).

The Bureau of Illuminating Engineering of New York.

We have received a letter from Mr. A. J. Marshall, well known as an illuminating engineer in the United States, informing us of his appointment as the Consulting and Chief Designing Illuminating Engineer to the Bureau referred to above,

Although the Bureau has been in existence for about two years, yet its wide and impartial method of treating problems of illumination has won wide recognition, including that of the United States Government, who have availed themselves of the services of the Bureau in the lighting of some of the Federal buildings.

Development of the Helion Lamp.

Mr. Walter Clark, in a recent letter to *The Illuminating Engineer*, mentions that considerable progress has been made by Prof. H. C. Parker and himself in the development of the helion lamp. This lamp, it will be recalled, utilizes a filament composed of a carbon core coated with a deposit of silicon, &c., by a special process, and is intended to burn at about 1 watt per c.-p.

We understand that it has now been found possible to burn these filaments in the open air without any enclosing globe whatever. Mr. Clark has kindly promised to send us a special communication on the subject very shortly, and we postpone reference to these interesting results until further details are available.

The Visit of the Société Technique du Gaz.

In our last number we referred to the visit of some of the gas engineers of this country to Berlin, where they were entertained by the Deutscher Verein von Gas- und Wasserfachmännern.

More recently about eighty of the members of the corresponding French society, including M. Coze, the president, paid a visit to this country, and were received and welcomed by representatives of the British gas industry. International greetings of this kind are becoming more and more common, and we need only again express our conviction of the immense value of these opportunities of meeting on the part of those representing different nations, and the feeling of good-fellowship to which they give rise, quite apart from the valuable information which those taking part are bound to receive.

The Development and Present State of Stage-Illumination

One would naturally be inclined to suppose that the modern cultured individual, living in an age of steam and electricity, and having at his disposal many sources of light of many different kinds, would apply this light with the object of enabling surrounding objects to be seen as they really are. An illustration that this is not invariably so is afforded by the objects and application of artificial light in theatres. Now, in this case light is mainly employed with the deliberate intention of creating illusions, and of presenting them in a complete fashion that would be impossible by ordinary daylight illumination.

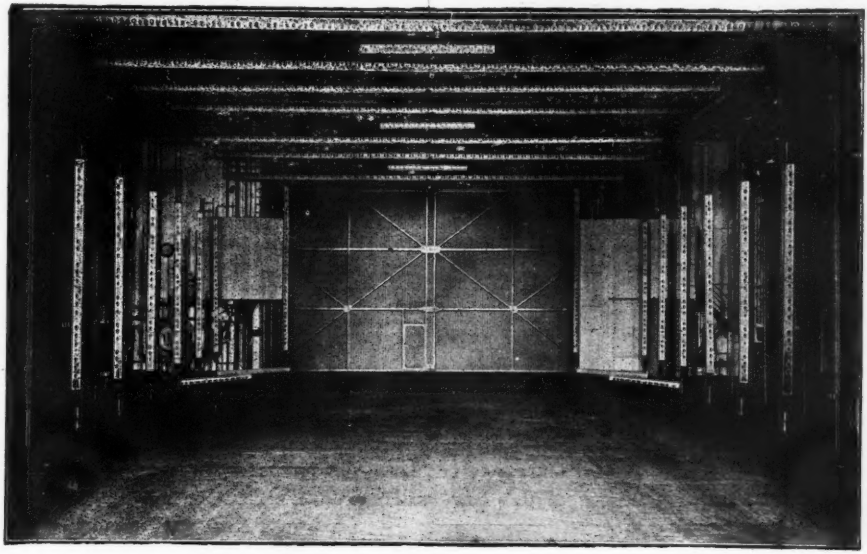


Fig. 1.

Theatres, complying with the high standard of the present day in the matter of scenic pictures, almost invariably utilize electric light. For electric light enables the countless and varied manifestations of natural daylight illumination to be imitated with a completeness that can be attained by no other artificial illuminant. Indeed, electricity is now so invariably utilized for stage illumination that it is hardly necessary, in what follows, to dwell upon the claims of other systems of lighting.

The introduction of electricity on the stage not only led to a complete revolution in apparatus for illuminating, but also in all other existing stage implements. We may therefore take this stage in the progress of theatre-lighting as a starting-point in the present discussion. When we consider what enormous labour was necessary in order to secure even the simplest and most necessary illumination effects previous to the introduction of electric light, it seems almost incredible that there should still exist at the present day theatres in which no use is made of electric illumination on the stage.

Previous to the introduction of gas

lighting, which found common application for stage purposes about the year 1830, it was usual to illuminate both stage and auditorium by means of oil lamps; we can therefore readily understand what difficulty was experienced in satisfying even the modest expectations of the public of that day.

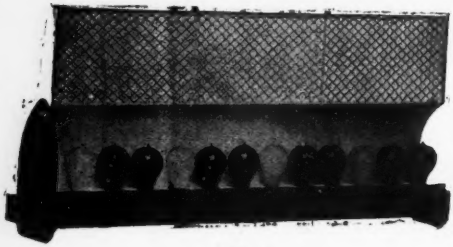


FIG. 2.

The functions of the arc light were then carried out by means of the Drummond limelight. Although the inconvenient and occasional dangerous nature of this illuminant were realized, it was only abandoned in the year 1880, when Siemens and Halske brought upon the market the first arc-lamp adapted to stage requirements. Subsequently the combination of arc and gas lighting was looked upon as the ideal method of stage-lighting. It was only in 1882, when the electric incandescent lamp came into use, that the disadvantages of gas lighting on the stage (development of heat, danger of fire, lack of flexibility and ease of regulation), were fully realized, and it was abandoned in favour of the new illuminant in all the larger theatres. From this point onwards a new era in stage illumination may be said to have commenced.

Stage lighting by electricity may be divided into two chief groups, namely:

1. *Glowlamp Illumination.*—In this category may be placed the footlights, the fixed lights in foreground, sides, and wings of the stage, and also the various portable fittings.

2. *Arc-light Illumination.*—In this class are included the searchlights ("limelight" as it is still usually termed), and many lamps for producing special effects, such as artificial lighting, &c.

1. GLOW-LAMP LIGHTING.

The illumination of most stages is, in the main, carried out by means of glow-lamps, which are utilized either in one, or in two, three, or four colours according to the size of the stage. The unicolour system, according to which only white lights are used, only comes in for consideration in the case of small or special stages and in amateur performances. In the case of all large or even medium-sized theatres, in which great demands upon the apparatus for producing scenic effects are made, three or four colour systems are invariably installed. In the former case there are four sets of fixtures which are equipped with white, red, blue, and green lamps respectively in equal numbers; in the latter yellow lamps are installed in addition. The different systems employed are subject to separate control, all the lamps, however, having a common return lead.

In considering the various types of fixtures employed on the stage we may distinguish between: foreground lights, which are utilized in the front portions of the stage; overhead lights, which are mounted in suitable reflectors, throwing the light downward, above the stage; side lights and lights in the wings. There are also a number of portable systems of lights which may

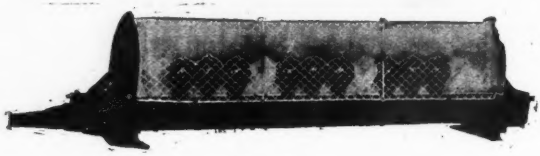


FIG. 3.

be stood on the stage in any desired position. Fig. 1 will enable a clear idea to be formed of the arrangement of some of these fixtures. It represents the general appearance of the stage seen from the extreme back, behind the curtain, of one of the largest German theatres.

The foreground lights are either built in the form of a permanent fixture, as is shown in Fig. 2, or take the form of portable arrangements of the kind shown in Figs. 3, 4, and 5.

The footlights, of course, form the boundary between the stage and the auditorium, and are distributed on either side of the prompt box. The footlights are intended to produce an evenly distributed light such that all persons and objects on the stage within a height of 2 metres are illuminated. In the interests of the actor an extravagant use of footlight illumination is to be deprecated. Light striking the eye from below in this way is very injurious. The author is inclined to think that irritation of the eyes of actors is more often to be attributed to this cause than to the effects of high general illumination, which is inevitable on the stage. Moreover, illumination by means of footlights may give rise to stripes and shadows, which cause effects which are often inconvenient and even comical. For instance, it may happen that shadows are cast on the actor's face by the ends of his false beard, with the result that he appears to the spectator to be equipped with two beards.

The overhead lights (Fig. 6), are mounted in such a way as to be capable of rotation about a horizontal axis, and can be fixed at any desired angle. The side lights (Figs. 7 and 8) are capable of a similar adjustment, and the light from them may be directed into the wings at any desired angle. For the production of bright sunlight glow-lamps of specially high candle-power are sometimes mounted over each side light; by this means a suitably high uniform illumination is produced over the entire stage, which can be strengthened or weakened between the desired limits.

The portable lights are arranged in various ways, some in the same form as the side lights shown in Figs. 2 and 3, others on suitable tripod stands of the

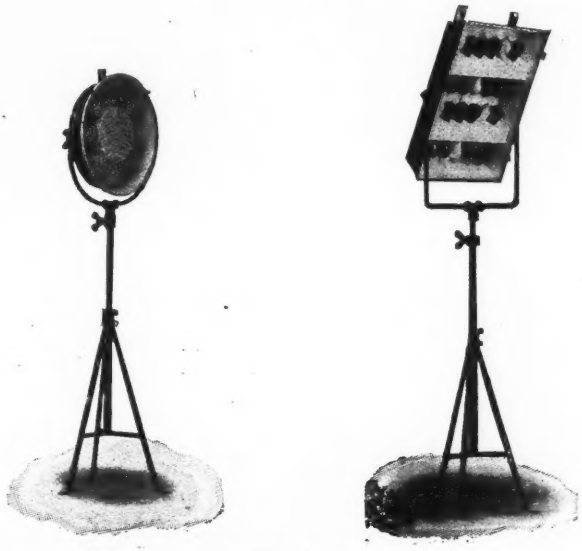


FIG. 4.

kind shown in Fig. 4. Here again a distinction is drawn between stands provided with lights of one colour and stands in which lamps in groups of three or four colours are mounted. Such a stand can be placed anywhere on the stage, the connexion to mains

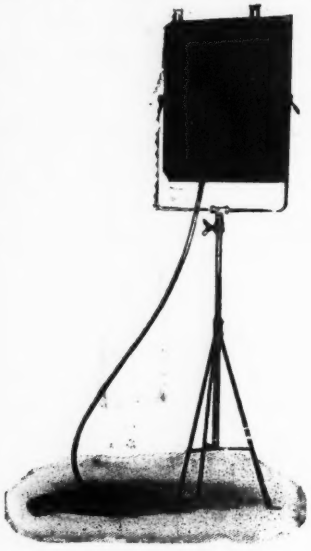


FIG. 5.

being made by means of a plug connexion and flexible wires.

The arrangement is thus specially well adapted for the illumination of certain regions of the stage independent of the general illumination or of certain objects or transparencies, &c., which require individual illumination, in order to achieve some special effect.

An example of the total lamp equipment of a modern theatre is furnished by the table at the conclusion of this article, which refers to the Opera House at Frankfort-on-Main. The sum total of the intensities of the glow-lamps used on the stage alone amounts to 74,502 H.K.

ARC-LAMPS AND APPARATUS FOR THE PRODUCTION OF SPECIAL EFFECTS.

By "effects" we usually understand the production of illusions by special means, and the imitation of special natural phenomena. Strictly speaking, the moonshine, sunrise, dusk, &c., should be included among these. As, however, these latter effects are mainly dependent upon the use of suitable rheostats and regulating devivices, also used for the general illumination of the stage, the arrangements for their production are not considered as belonging to the apparatus for furnishing special effects.

This "effect lighting," in contradistinction to the main lighting of the stage, is chiefly accomplished by the use of arc-lights. Scenic effects commonly involve the use of searchlights and projectors. Notable instances of their use occur in the ballet, in "transformation scenes" and other "grand spectacles." Searchlights are employed to illuminate certain objects on the stage which it is desired to bring into special prominence. Projectors are utilized to throw images of sta-

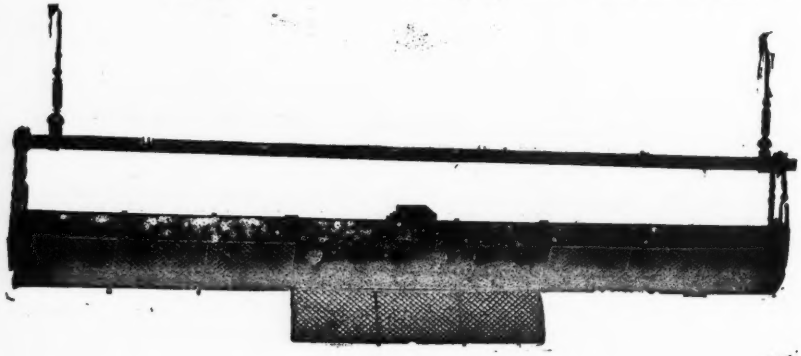


FIG. 6.

tionary and moving objects upon a screen, and so simulate the appearance of driving clouds, falling snow, rain, rolling waves, or the rising of the moon, &c. Besides being as freely movable as possible about vertical and horizontal axes, these pieces of apparatus must also be capable of standing firmly on a very narrow pedestal and of being fixed in certain positions on the stage that are not readily accessible by other means. By means of special clamps they can also be firmly attached to tables or other objects without requiring any additional under-support. An adjustable rheostat is introduced into the circuit for the purpose of controlling the light.

As a rule the searchlight and the projector are not in use simultaneously. Consequently an adjustable combined piece of apparatus is used which can serve either purpose, and really is equivalent to doubling the number of searchlights or projectors available.

Combined arrangements of this kind are shown in Figs. 9 to 12. For the purpose of modifying the colour of the light emitted screens of the four shades of colour commonly used on the stage are provided. When it is desired to change colours suddenly—in a snake dance, for instance—these coloured screens are mounted in suitable opaque supports, and are rotated by hand about a horizontal spindle in front of the objective of the instruments as shown in Fig. 9.

In order to simulate clouds, rain, &c., transparent screens, on the face of which the desired quality of clouds, &c., are painted, are used. These transparent screens are mounted in a cylindrical vessel and driven by clockwork.



Fig. 7.

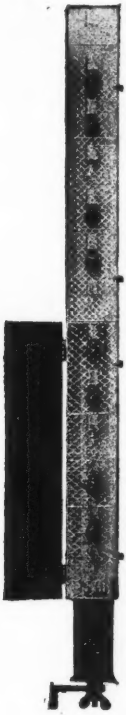


Fig. 8.

In this connexion reference may be made to a novel device, having for its object the exact imitation of daylight. The new method seems likely to effect a complete revolution in the previously employed methods of attaining this end.

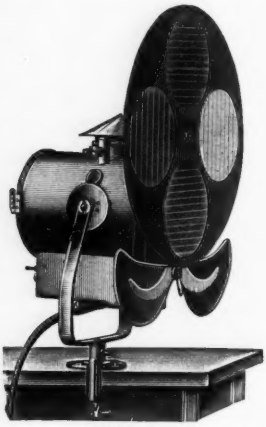


FIG. 9.

Hitherto it has been usual to utilize the light from glow-lamps for the purpose, which, however, are not entirely suitable on account of the fact that the yellow tint of the light yielded by them differs considerably from the whiter sunlight. Hence it has recently become customary to use the arc-light for this

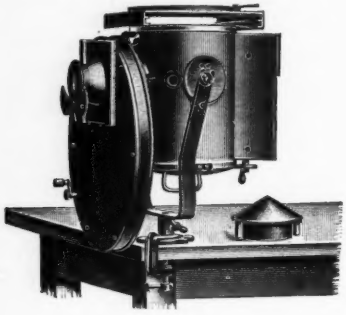


FIG. 10.

purpose. A well-regulated continuous current arc-light yields light exactly resembling natural daylight in colour. The inverted arc-light is particularly effective for this purpose, being exceedingly well-adapted to the production of delicate shades of colour. According to the Fortuny system, the light from the arc-light is thrown upon suitably coloured silk surfaces, and thence reflected on to the stage. A further advantage of the system is that, with an arc-lamp one can, owing to the economy of arc-lamps, with the same current-consumption obtain about two to three times the intensity that is possible in the case of carbon filament glow-lamps.

We must not forget to mention the special arrangement of lamps for the production of lightning. To produce



FIG. 11.

this effect a series of arc-lamps are spaced in the gaps among the overhead lights, and can be lighted up one after another in rapid succession by the use of a special quick break switch. Portable "lightning lamps" are also sometimes placed in different positions on the stage, with the object of accentuating the illusion.

Stage Regulating Resistances.

The regulation of the entire lighting of a theatre, both as regards colour and brightness, is accomplished by special regulating resistance—one of the most important pieces of apparatus used on the stage. In this resistance the control of all the various groups of lamps is centralized, so that any group can be dimmed or extinguished at will. In order to render this result



Fig. 12.

possible separate resistances are placed in series with each individual group of lamps, and the steps by which the resistance can be varied are so finely divided as to enable an infinite series of gradations between darkness and complete brightness to be produced.

Space does not allow of a complete description of this piece of apparatus, but an idea of the size of the whole arrangement will be gathered from Fig. 13. Very complete control over the whole effect is obtained by utilizing a large number of separate systems of lamps spaced about the stage and all separately adjustable. As a result it is possible to vary not only the intensity, but also the colour of the light from each, and not only to gradually alter the general illumination, but to secure any desired shade of colour, and a very gradual transition from one colour to another.

The position of this regulating resistance must be such as to enable the operator to view the entire stage, and, possibly, the auditorium, so as to observe the exact effect of any

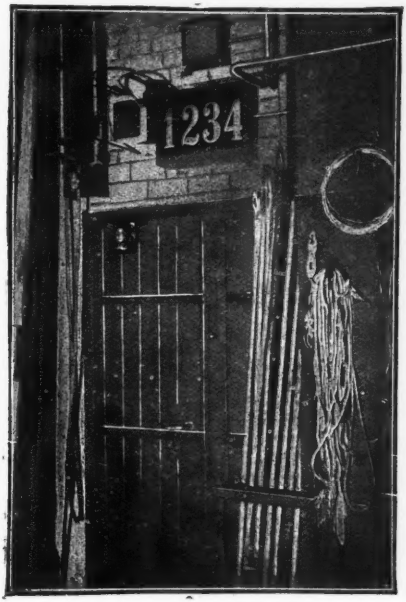


Fig. 14.

alteration in the illumination on which he is engaged. It will be seen that the position of the resistance in Fig. 13 allows this to be done.

Signalling Lights and Apparatus.

Special importance attaches to the methods of signalling employed in a modern theatre. Such signals are commonly conveyed by the lighting up or extinguishing of white or coloured glow-lamps, by which instructions as to lowering or raising of pieces of scenery, trap-doors, curtains, &c., are given

or messages from the stage manager, conductor of the orchestra, or prompter communicated.

Among these may be mentioned an electrical device for beating time by the aid of which the conductor can give the time to those standing in many different positions of the stage. A number of glow-lamps—two, three, or four as the time may demand, are utilized to illuminate certain parts of a screen, visible to all the performers. This arrangement is shown in Fig. 14. The lamps are controlled by the conductor, being lighted and extinguished as he presses or releases certain

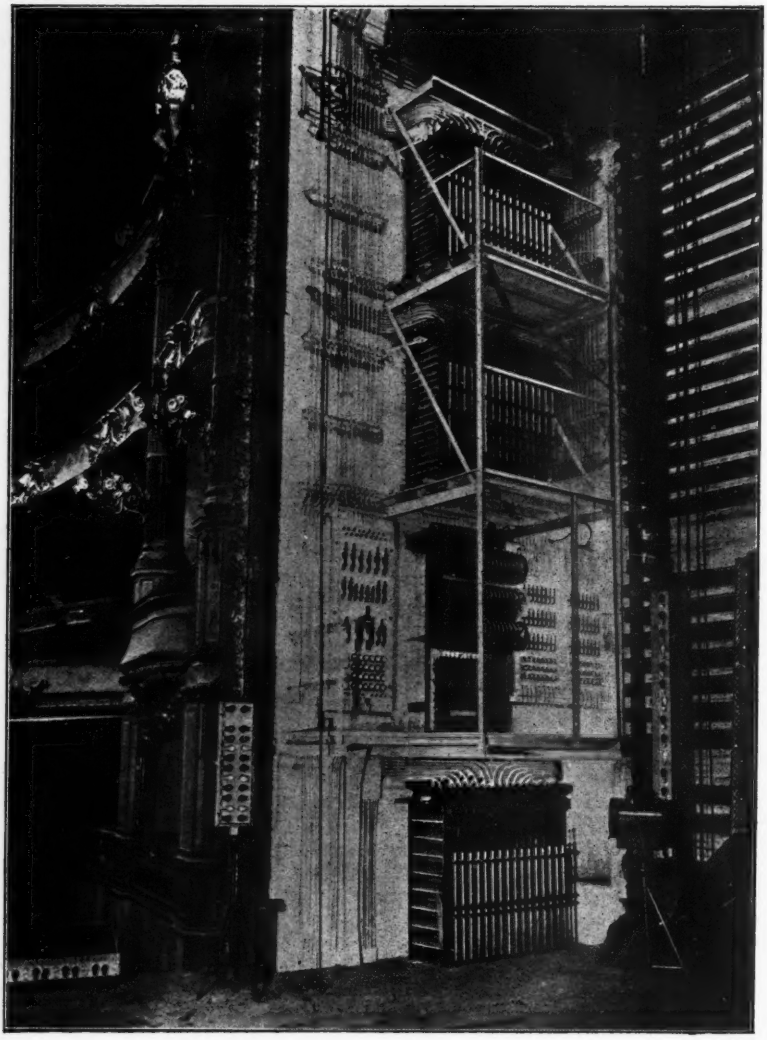


FIG. 13.

TABLE I.

Showing the number of glow-lamps in use for various purposes on the stage of the Opera House at Frankfort-on-Main

Number.	Nature of Fitting.	Length of each Reflector m.	Number of Lamps.				
			White 32 c.-p.	White 25 c.-p.	Red 25 c.-p.	Blue 25 c.-p.	Yellow 25 c.-p.
1	Foreground ...	12	26	—	26	26	26
6	Wings	16	—	144ea=864	—	—	—
6	,, ...	16	—	—	52ea.=312	52ea.=312	52ea.=312
1	Wing	10	—	86	—	—	—
1	,, ...	10	—	—	32	32	32
2	Front Side-Lights	5	22ea.=44		22ea.=44	22ea.=44	22ea.=44
1	Rehearsal Lights ...	2	20	—	—	—	—
12	Portable Front Side-Lights	1	10ea.=120	—	—	—	—
12	Portable Front Side-Lights	3	7ea.=84	—	7ea.=84	7ea.=84	7ea.=84
2	Portable Lights with Conical Reflector	—	10ea.=20	—	—	—	—
2	Portable Lights with Conical Reflector	—	19ea.=38	—	—	—	—
2	Portable Lights (4 colours) ..	—	7ea.=14	—	7ea.=14	7ea.=14	7ea.=14
2	Portable Lights (1 colour)	—	10ea.=20	—	—	—	—
			386	950	512	512	512

Total Number of Lamps, 2,872.

keys. On account of the rapidity with which such lamps light up and go out again, metal-filament lamps are specially adapted for this purpose.

In this article, which deals exclusively with stage illumination, no attempt has been made to describe the many other interesting applications of electricity to the stage. In conclusion the author wishes to express his acknowledgment of the courtesy of Messrs. Siemens Bros., Ltd., who kindly furnished blocks for the illustration of this article, and gave information on many points of interest.

F. S.

The Methods of the Stage Applied to Shop Lighting.

THERE are many practical cases in which the salesman would do well to take a leaf from the book of stage-craft in arranging the goods he is trying to induce the public to buy.

He is not, of course, expected to devise mechanically driven moons, snowstorms, or moonlight. But yet he is faced with a similar problem to that met with in stage lighting—namely to arrange his windows so as to attract and hold the attention of the passer-by who constitutes his "house." Therefore his display must be at once striking and pleasing to look at.

Some of the best methods of shop lighting involve the use of lights in a manner analogous to footlights on the stage, and there is room for endless possibilities in the way of directing the light so as to call attention to certain exhibits, and in the judicious use of transparencies and other luminous devices.

On Shades and Reflectors and the Diffusion of Light.

THE last few years have led to remarkable progress in the efficiency of artificial illuminants, and the attention which is now being bestowed on methods of using and distributing light is leading to, at least, equally valuable results.

Naturally it is of little use to be able to produce light efficiently if the light we have been at such pains to produce is wasted in an inefficient globe or fixture, or is allowed to cause actual injury or inconvenience to those whom it is intended to benefit. From this point of view the design of the actual lighting fixture in which the lamp is installed may be seen to be very important indeed. The increasing intrinsic brilliancy of the new illuminants almost compels the consideration of the proper placing and screening of sources, and their greater efficiency also enable us to make some economical sacrifice, in order to obtain pleasant working conditions.

In arranging lights in a room, and in designing shades and fixtures, we have usually a two-fold object in view. In the first place we wish to protect the eyes from the fierce brightness of the unshaded source of light. Secondly, we wish to concentrate our light in the directions in which it is most needed.

The use of diffusing globes, made of opal or frosted glass, &c., and reflectors, has certain definite advantages. Prof. Basquin has estimated the average brightness of the sky at about 2·5 candle-power per square inch, and Dr. Louis Bell has given 5 candle-power per square inch as the maximum permissible limit. Evidently, therefore, supposing that the light from the source is distributed evenly over the surrounding globe, there need be no difficulty in providing a shade of sufficient superficial area to bring its brightness per unit area below the permissible limit, at any rate, in the case of lights below 100 candle-power, such as are used in most interiors.

There are, however, other points to be considered which render the use of opal glass, frosted glass, &c., in itself hardly sufficient, though this method may be very useful in connexion with other devices. In the first place it is inevitable that if any such glass is sufficiently dense to cause the entire surface to be evenly illuminated it must absorb a considerable amount of light—it is known that very dense glasses of this kind may absorb upwards of 50 per cent. Researches by Hyde and Cady have likewise shown that the useful life of lamps with frosted globes is very seriously diminished. Secondly, it is clear that in the case of shades of this description the *distribution* of light from the source is not under control. For the globe may become an illuminating source, radiating light evenly in all directions, or, if it is not sufficiently dense to appear evenly illuminated all over, we merely obtain a polar curve of distribution intermediate between that corresponding to the above conditions and that of the source of light itself.

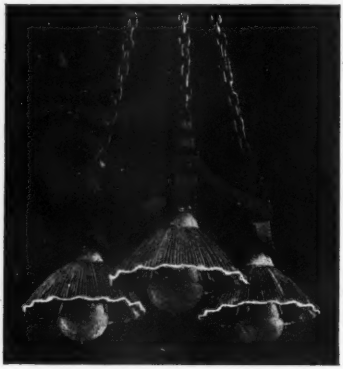


FIG. 1.

A more perfectly scientific method of diffusing and distributing light lies

in the development of globes and reflectors made of cut glass.

Cut-glass shades, which are not contrived on scientific principles, are objectionable in many ways. They are often of very little real service in diffusing the light, only breaking it up into irregular bright patches which annoy the eye almost as much as the bright surfaces they are intended to screen. In addition to this the thickness of the glass, and the fact that the cut edges, being placed hapazard, often reflect the light to and fro within the globe instead of allowing it to escape, are often responsible for a considerable loss of light.

For the scientific development of glassware of this description great credit is due to the Holophane Co., who have put on the market an extraordinary variety of shades and reflectors, all intended to produce certain specific effects. We do not propose, in the present article, to enter into a detailed description of the scientific principles underlying fixtures of this class. Briefly their object is attained by the use of ribbed or prismatic glass, in which these ribs or prisms are so shaped as either to bend and transmit the light in any desired direction, or to totally reflect it. Glass made on these principles may, therefore, either be utilized as a reflector or as a transmitting shade. In either case the light can be either evenly diffused or concentrated in any direction, according to the nature of the shade or reflector employed, and the loss of light has been found to be a minimum, being, under favourable conditions, as low as 10 per cent.

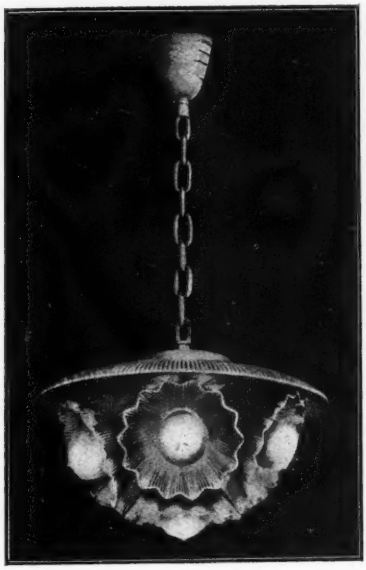


FIG. 2.

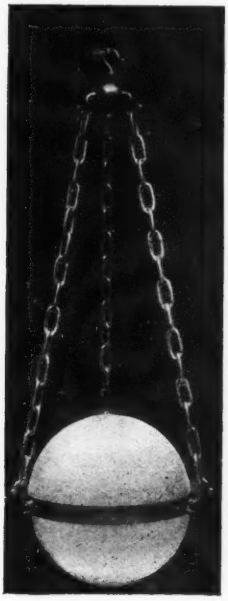


FIG. 3.

In Fig. 1 is shown an illustration of the use of these reflectors with frosted tungsten lamps, in order to concentrate the light in a downward direction. Fig. 2 shows a similar arrangement applied to a cluster of tungsten lamps, and termed a "holophane arc."

An entirely different type of fixture is the diffusing globe shown in Fig. 3. These globes are made in various sizes,

so as to include one or more lamps of different candle-power. When in use they appear evenly illuminated all over; they may, however, be so constructed as either to throw most of the light downwards, or upwards on to the ceiling, as may be required.

A verandah illuminated by a series of globes of this kind is shown in Fig. 4.

In choosing these holophane globes and reflectors special attention should be paid to the exact purpose for which they are intended, and the type of lamp with which they are to be used. For example, standard types of shades and reflectors are designed for use with tantalum or osram lamps, incandescent mantles, &c., and can be arranged either to distribute the light or to concentrate it immediately below the lamp, as required.

One feature of the development of shades and reflectors in the United States, which is worthy of special mention, is the standardization of certain "units," that is, the design of a certain diffusing globe or reflector only supplied in conjunction with a certain type of lamp—fixture, shade, and lamp complete.

The result of establishing a system of this kind is that naked filament lamps fall out of fashion, and it becomes a recognized and accepted fact that a lamp must always be provided with a suitable shade so as to diffuse and distribute its light to the best advantage.



FIG. 4.

In this article we have only attempted to touch in a general fashion on the subject of reflectors, diffusing globes, and fixtures generally. The subject is now an exceeding important and wide one, and we propose to publish a series of articles dealing with various aspects in greater detail in the near future.

The Illumination of Railways by Acetylene.

In the course of this article we propose to study two entirely distinct questions, namely :—

The illumination of railway stations by acetylene.

The illumination of railway carriages by acetylene.

These two problems are really quite distinct, and present different difficulties. In the first case we have to provide illumination for the buildings, platforms, &c., without being obliged to make very exceptional provision for the nature of the place the lights are intended to illuminate, or being greatly concerned with the length of time during which the sources of light will burn without attention. In the second case, on the other hand, we must endeavour to secure above all things that the lights shall burn continuously throughout the entire run of the train, and also to avoid fixtures and apparatus of a cumbersome nature.

The Illumination of Railway Carriages by means of Acetylene.

In the first place it may be understood that acetylene will probably not find application for the purpose of lighting stations, &c., near to large towns, as these will naturally be provided for by gas or electricity. But when we come to consider small country stations, and small towns, which it does not pay to illuminate either by gas or electricity, acetylene finds a useful field of application.

As a matter of fact one finds that many such stations are commonly illuminated by petroleum lamps. However, not only does such lighting cost more than acetylene, but it also entails a large staff to be kept up in order to keep these lamps in proper working condition. As a result it not infrequently happens that small stations are equipped with petroleum lamps which might burn well if properly looked after, but actually go out, smoke, or smell disagreeably because it is impracticable to keep the necessarily small staff of the station constantly engaged upon the wearisome duty of attending to them.

In the case of acetylene, on the other hand, there is no trouble of the kind. All that is necessary is to attend to the apparatus once a day at most, and to change the burner occasionally, in order to secure as bright an illumination as any one could desire. In such a case it is understood that all the lights are fed from the same central generator.

Either acetylene flames or incandescent mantles may be used. The first method is possibly the simpler of the two ; the second is undoubtedly the cheaper. Both methods are equally applicable to the lighting of the interiors of buildings and to the illumination of platforms.

The progress of acetylene lighting applied to railway stations has been most remarkable in Austria, being generally adopted by the Northern Railway. In France several railways are illuminated by acetylene, and the State railways utilize incandescent acetylene lighting by means of burners of small consumption. In America, acetylene has been adopted not only in stations, but also for signal-lights ; in the latter case dissolved acetylene is preferably employed.

The Lighting of Railway Carriages by Acetylene.

Although the problem of train-illumination is an exceptionally interesting one, and in spite of the fact that a number of experiments in the subject have been carried out by railway companies of recent years, it is only recently that any really practical solutions of the problem have suggested themselves. On the other hand, it is a fact that the methods of lighting in use in trains have hardly kept pace with the great progress that has recently been made in artificial lighting, and for the simple reason that

they cannot be easily applied under the particular circumstances called into play.

Leaving out of account acetylene, what other illuminants are applicable for this purpose? Electricity and gas at once suggest themselves.

It would seem simple enough to apply electricity to train lighting. What is easier than to utilize the engine driving the train to drive a dynamo in addition? Unfortunately, however, trains are not invariably in movement, and light is still a necessity to travellers even when the train is standing still. Hence it becomes necessary to utilize accumulators to take up the load when the dynamo is not running. Unluckily, again, accumulators are very fragile things.

As usually arranged, the accumulators are charged when the train is running at full speed, and the P.D. of the dynamo rises above that of the cells; on the other hand, when the train is still, or running comparatively slowly, the cells discharge Thus, owing to the general irregularity in the treatment to which such accumulators are subjected, the plates tend to buckle, and very rapidly deteriorate.

One may, of course, utilize a separate special engine to drive the dynamo. The running of the dynamo, however, would be affected by the vibration and shock of the motion of the train, and also variations in the pressure in the boiler would result in a very fluctuating light.



FIG. 1.—Interior of Railway Carriage Illuminated by Acetylene.

A third possibility would be to light the lamps of the train solely by means of a group of accumulators which are completely charged before the train starts, and recharged when the journey is ended. But accumulators are very heavy, their capacity for a given weight is limited, and it requires a considerable length of time to recharge them. It is also hardly worth while to adopt the laborious plan of replacing the battery which has run down by one newly charged. On the whole it may

be urged that electricity is hardly adapted to train lighting.

Coal-gas, burnt by means of flat-flame burners, may also be employed. In order to obtain enough light in the case of a carriage divided into six compartments, we should require ten burners, each burning about 100 litres of gas per hour, or one cubic metre per hour in all. During the winter an ordinary carriage in a night train would, therefore, require about 15 cubic metres of gas. Therefore if we imagine the gas to be compressed under a pressure of ten atmospheres, it becomes evident that each carriage must be furnished with a gas-carrying vessel of one and a half cubic metre capacity, if we wish to avoid being obliged to recharge *en route*. This enormous bulk might be reduced to 300 litres at a pressure of 10 atmospheres, or 3 cubic metres at ordinary pressures, by utilizing incandescent mantles, and would, of course, also constitute a saving in consumption of gas.

But here again incandescent mantles are very fragile, and come to pieces very easily when subjected to the continual jar and shock of the train. The continual renewal adds to the cost of the lighting, but, worse still, the mantles may break during the journey at a time when it is very inconvenient to replace them, and, as the flames used with them give practically no light, the carriage is plunged into sudden darkness.

Four distinct methods of utilizing acetylene for train lighting are in use :

1. Lighting by acetylene gas in the ordinary way, several burners being employed, fixed at convenient positions in the carriage to be illuminated, and supplied from a generating system.

2. Lighting by means of a mixture of acetylene and rich gas (the Pintsch mixture).

3. Lighting by compressed acetylene.

4. Lighting by means of acetylene dissolved in acetone.

We will consider each of these methods in turn.

1. Ordinary acetylene lighting is scarcely used except in American trains. The method, while very convenient for the purpose of lighting a vehicle furnished with four or five burners or more, to be illuminated for six or seven hours at a stretch, is less easy to apply in the case of a railway carriage, in which the great number of burners to be fed and the long time during which they are needed necessitates the use of an apparatus of considerable size for each carriage. Thus, in the case of a carriage lighted by ten burners, each consuming 20 litres of gas per hour, we require 3 cubic metres of gas to last through a winter night. This corresponds to a charge of 10 kilos of carbide, which means a generator inconveniently large. In such a case it would almost be necessary to reserve a special compartment for the generator. However, this method, as we have stated previously, has only been used to any extent in America, where it was considered necessary, cost what it might, to provide each carriage with exceptionally good illumination ; it is no worse than any other method of lighting, but presents no special advantage.

2. Pintsch gas consists of a mixture of 25 per cent acetylene and 75 per cent of a rich quality of gas obtained by the distillation of " boghead," a variety of bituminous shale found in Scotland, France, and Australia. It would be out of place in this article to enter into the qualities of this Pintsch gas. It may, however, be mentioned that the rich gas and the acetylene are manufactured separately at the works, mixed in the desired proportion, and then compressed at 10 atmospheres in enclosing vessels similar to those used for compressed illuminating gas of the ordinary variety. It has been found that, in the case of the Pintsch gas, this pressure is quite safe.

These reservoirs are used to fill suitable vessels placed in each carriage. The pressure in this latter case is 7 atmospheres, the gas being, however, supplied to the burner at a convenient pressure of 55 millimetres of water. The capacity of the vessels employed for the lighting of a single carriage varies considerably, but, as a rule, contain sufficient gas at 7 atmospheres to light all the burners in the carriage for 35 hours. The burners themselves

consume 25 litres per hour, and yield a light of about 12 to 13 candles. In France the cost of one "bougie"-hour in the case of Pintsch gas amounts to 0·0017fr., less costly than the rich gas alone, but dearer than acetylene.

Pintsch gas has long been one of the most practical methods of train lighting. It was first employed in Germany, especially upon the Prussian railways. It has also been used in France, on the lines of the Paris, Lyons, and Mediterranean Railway, and in America there are also a number of companies who make use of the method.

However, the Pintsch gas can only be regarded as an intermediate step from rich gas to acetylene. It was a long time before any practical method of reducing acetylene gas to small bulk was devised. Nowadays it is not only possible to compress acetylene, but also to dissolve it and extract it from solution as required. Now that these methods have been brought to a practical stage the Pintsch gas has no longer any valid reason for existence. By the advice of the inventor himself, it has been abandoned in almost all the cases in which it was formerly employed.

3. The apparatus used for lighting by Pintsch gas may also be employed with compressed, but not dissolved acetylene.

Although there is no particular difficulty in compressing acetylene, it is only a few years since this method has found practical application. First of all it would be unwise to propose to store compressed acetylene, as is done in the case of the Pintsch gas, in a vessel containing no solid matter. Under these circumstances acetylene could not be used without danger. In order to compress acetylene with impunity some porous substance is included in the containing vessel, and the pressure is carried up to 10 atmospheres. By taking the precaution to introduce this porous matter, it is possible to use acetylene gas with the old Pintsch apparatus, and thus avoid the expense of total renewal. The change to acetylene carries a double advantage. Not only is the illumination more satisfactory, but, for the same intensity of illumination, the vessel which formerly contained enough Pintsch gas to enable the carriage to be lighted for 35 hours, will hold enough acetylene to last for 175 hours. We may therefore either elect to increase the illumination or to enable the reservoirs to remain for a longer time without recharging.

The storage of acetylene in these vessels is accomplished in exactly the same way as in the case of the Pintsch gas. All that is necessary is to put the vessel in communication with a supply at a pressure slightly in excess of that which will be actually employed.

For this purpose the works are usually provided with reservoirs containing acetone. The possibility of rapid storage is the sole advantage of compressed over dissolved acetylene.

4. Dissolved acetylene is, in the writer's opinion, best suited for the illumination of railway carriages. It may be well to explain briefly in what this process consists. Acetone, a comparatively cheap liquid, possesses the remarkable property of dissolving about 240 times its own volume of acetylene, at a pressure of 10 atmospheres and a temperature of 15 degrees. At atmospheric pressure acetone will only dissolve about 25 times its own volume. Therefore a vessel of acetone, saturated with acetylene gas at a pressure of 10 atmospheres, will liberate 215 times its own volume when the pressure is reduced to ordinary atmospheric value.

In order to avoid danger, acetylene is dissolved in acetone contained in tubes filled with a special extremely light, porous material which absorbs the acetone freely. In such tubes of 1 litre capacity it is possible to imprison 100 litres of acetylene. Therefore we are able to compress very great reserves of acetylene in an exceedingly small pace, which, of course, is exactly what is required in train-lighting.

For long journeys, which are very frequent in America, tubes of great capacity are employed. These tubes are supplied with acetylene at the works, or from portable cisterns sent to various stations on the railway for

the purpose. During the process of charging the vessels may remain in position on the train. The charging, however, takes a comparatively long time, and it is, therefore, necessary to arrange to make stoppages at the works or at feeding centres. In the case of short voyages one uses by preference tubes of relatively small capacity, replacing them, as soon as they are empty, by others filled at the works.

Acetylene is burnt in burners of the ordinary variety, consuming 15 to 20 litres of gas per hour. Since the open flame itself has a considerable illuminating power, it is hardly advisable to employ incandescent mantles, on account of their fragility. The mantles are, however, much stronger than those used with ordinary gas.

Lastly, a few interesting instances may be given of the performances of acetylene lighting in trains.

In 1902 the American Lackawanna, and Western Railway Co. decided to equip their carriages with dissolved acetylene. The reservoir containing acetylene was to feed 13 burners. The charging was carried out on March 4th, 1902, and the lighting was assured-until May 12th in the same year before it became necessary to recharge. The actual lighting hours were in this case 260.

A train, lighted by dissolved acetylene, which was blocked in a snow-drift on the North-West Line, was able to supply light without interruption for 12 days.

In the year 1902 a very important experiment was undertaken by the following 13 companies: The Delaware Lackawanna Railway Co., Erie Co., Cincinnati Co., Richmond and Muncie Co., Atlanta and West Point Co., Chicago, Rock Island, and Pacific Co., St. Joseph and Grand Island Co., Western Maryland Co., St. Louis South-Western Co., Missouri Railway Co., Kansas and Texas Railway Co., Atchison, Topeka and Santa Fé Railway Co., and the Canadian Pacific Co.

A carriage 21 metres in length was to travel over the lines of these railways. The carriage was to receive a total amount of light of 450 candle-power, furnished by a tube of dissolved acetylene 3 metres long and 0·50 m. in diameter, containing dissolved acetylene at a pressure of 16 atmospheres.

The carriage departed on May 25th from Chicago for Denver, and accomplished the go and return journey 35 times, *i.e.*, a total distance of 137,000 kilometres. The tube was first recharged on Jan. 5th, 1903, and a second time on March 10th. It had furnished light for 140 complete nights; a single charge thus supplied the carriage with light for 70 nights. In consequence of this record several of the companies decided to adopt dissolved acetylene, and all the companies are gradually following suit. At the present time 3,000 carriages are thus lighted in America.

Among other countries in which dissolved acetylene is used on trains we may mention Austria, Italy, and Russia. Most other countries, including France, are at present undertaking tests of the method. R. G.

The Acetylene Convention in Chicago.

THE Eleventh Annual Meeting of the International Acetylene Association will be held in Chicago on August 10th–12th of this year. We understand that some papers of special interest will be read before the meeting, and that there will be visits and social entertainments arranged.

The Meeting of the Societe Technique de l'Industrie du Gaz.

At the thirty-fifth annual meeting of the above society, which took place in Paris from June 23rd to 26th of this year, a number of papers dealing with subjects more or less closely related to illumination were read. **M. Vautier,** well known as the chairman of the International Photometrical Commission which met at Zürich last year, briefly summarized the proceedings of the last Congress, and drew attention to the table connecting the relative VALUES OF THE CARCEL, HEFNER, PENTANE, AND BOUGIE-DECIMALE.

M. Denayrouze described his method of utilizing certain HYDRO-CARBON PRODUCTS from coal-tar FOR INCANDESCENT LIGHTING. Such liquids had previously been utilized in conjunction with alcohol, and more recently pure benzol has been used for the purpose in the form of the Lusol lamps now in use in Paris. M. Danayrouze's system seems to have consisted mainly in the utilization of other liquid derivatives, which are claimed to be exceedingly easy and cheap to manufacture.

M. C. Bachelay gave an account of a form of SAFETY DEVICE FOR SUSPENDED FITTINGS.

M. Berthelon described the SECURITAS APPARATUS, which enabled the gas to be cut off at the meter during the night from a switch in the bedroom by means of pneumatic arrangement. This apparatus is, of course, intended as a boon to nervous people who are afraid of escaping gas in the bedroom, and like to have the gas turned off completely before retiring to rest.

M. Henri Roger explained a form of GAS-LIGHTED LUMINOUS ADVERTISEMENT, in which the gas from the mains was caused to light up and extinguish the sign at regular intervals; the method could also be applied to illuminated signs working in two colours.

M. Meker gave some details of IMPROVEMENTS IN GAS-BURNERS, chiefly centring about the design of the mixing tube, and resulting in a gain in efficiency of about 20 per cent.

M. Laforgue described a number of NOVELTIES IN GAS-LIGHTING. These included some details of the Esperanto mantles, which, it is claimed, yield 120 candle-power initially, and still give 100 after 1,000 hours' burning. Tests by Dr. Bunte were also quoted to the effect that a maximum light was obtained in thirty hours, and retained undiminished for about 150 hours afterwards.

M. A. A. Defoy described the method of LIGHTING RAILWAYS BY INVERTED INCANDESCENT GAS-MANTLES on the compressed oil-gas system used on the lines of the West of France railway. The mantles were stated to have given excellent results, special precautions being taken to reduce the shaking to a minimum, and it was further stated that the method will be extended to all the trains of the company very shortly. The southern and northern railways are also experimenting with the same system, with a view to its adoption.

M. M. E. Thomine read a short paper dealing with HIGH-PRESSURE LIGHTING, and in doing so referred to the progress that had been made in England in this direction, as exemplified by the installations in various streets in London and the Keith lighting, now on exhibition at the Franco-British Exhibition.

M. R. H. Gaulis gave an account of the AUTOMATIC EXTINGUISHING APPARATUS constructed by his own firm in Switzerland, including a distance-extinguisher actuated by waves of pressure from the gas supply.

Economical Aspects of the Various Illuminants.

A RECENT article by A. A. Wohlauer in *The Electrical World* (N.Y.) contains an exceedingly complete and up-to-date review of the relative economies of the various modern electrical illuminants.

The difficulty of deciding upon the best illuminant to be used under certain circumstances is accentuated by the great number of different lamps now at the consumer's disposal. Probably no one would think of utilizing a flame arc for indoor illumination, or a mercury arc in a ballroom. In the same way there are certain qualifications, possessed by certain illuminants, which render them specially adapted to some situation, and might result in the cost being regarded as comparatively unimportant. For instance, incandescent glow lamps might often be utilized to produce some desired decorative effect, on account of their adaptability and the ease with which they can be fitted into any required position, notwithstanding the fact that some other illuminant could produce the same amount of light at a lower cost. Again, we can readily understand that the architect concerned with the illumination of some building of great historic associations might frequently feel that mere efficiency could be disregarded in view of the greater importance of attaining sympathy with the traditions of the past. Subject to

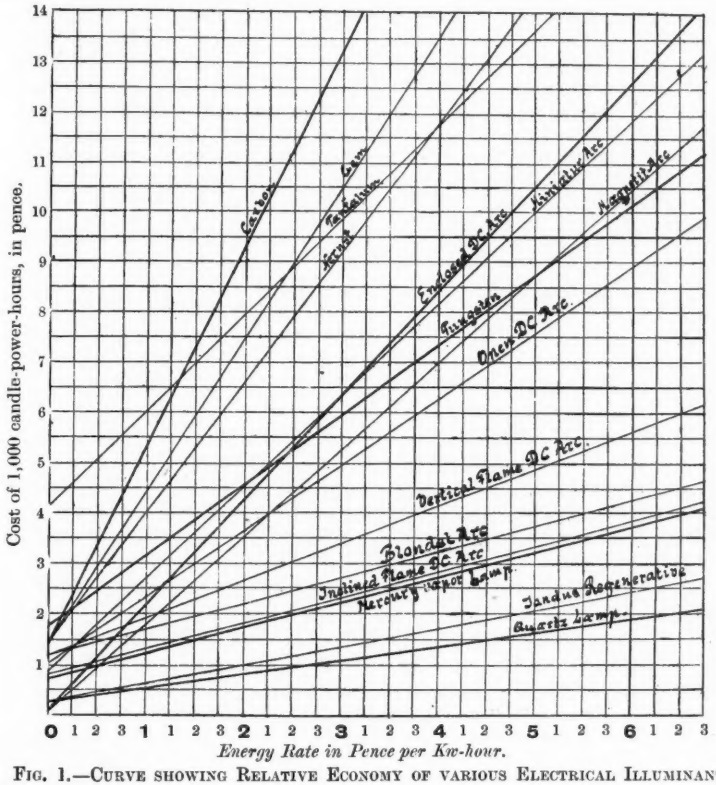


FIG. 1.—CURVE SHOWING RELATIVE ECONOMY OF VARIOUS ELECTRICAL ILLUMINANTS.

certain limitations, however, it may be said that the deciding factor in many practical cases is the question of cost, including both renewals and maintenance and the cost of energy.

Furthermore, the author points out, recent developments have distinctly disarranged and shifted the relative territories of the various lamps. The enclosed arc now finds a formidable competitor in the high candle-power tungsten lamp; the flame arc may prove to have a similar competitor in the quartz-tube mercury lamp, &c.

The author does not consider depreciation and interest on invested capital, as these do not materially influence the cost per candle-power hour, and are, in addition, so dependent on special circumstances as to be outside the scope of general rules.

In the table are shown the relative costs per candle-power hour, reckoning different rates per unit of energy. The results are worked out in terms of the mean spherical intensity of the sources, which the writer regards as, on the whole, the best basis of comparison. It is true that occasionally the mean hemispherical candle-power is most important in an illuminant; but this again involves the reflecting qualities of different reflectors, which vary among themselves very greatly.

The cost of renewal and maintenanee is taken as $\frac{P \times 1000}{l \times L_s}$, where L_s means the mean spherical candle-power,

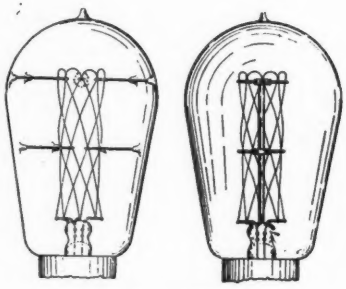
l, life of *lamp* in the case of incandescent lamps; *glower* in the case of Nernst lamps; *electrode* in the case of arc lamps; *vapour-tube* in the case of vapour-tube lamps.

P, price of *bulb* in the case of incandescent lamps; *renewal of glower and ballast* in the case of Nernst lamps; renewal of *electrodes* and *trimming* for arc lamps; *tube* for vapour lamps.

A Recent Patent Referring to Metallic Filament Lamps.

(From *The Electrical World*, May 16.)

A DISADVANTAGE encountered in electric lamps of the metallic filament type resides in the extreme fineness of the filament, which renders them liable to breakage. Mr. Hans Kuzel, of Baden, Austria-Hungary, on May 5 obtained a United States patent for a method of supporting the filaments so as to eliminate the liability to breakage, and to prevent such deformation of the loops of the filaments when hot as to cause short circuits. The filaments are supported from a central stem or from the walls of the bulb by eyelets which are so arranged that the filaments are wound helically, as shown in the diagram.



KUZEL INCANDESCENT LAMP.

SPECIAL SECTION.

Some Notes on Illumination at the Franco-British Exhibition.

THE arrangements at the Franco-British Exhibition, though still not quite complete, afford an excellent illustration of the different methods of interior and outside lighting now available. It is not often that the public have an opportunity of seeing so many different systems of lighting collected together under such pleasant conditions, and in the present case the interest is heightened by the exhibition of several of the most recently introduced lamps, and the scale on which the general illumination is carried out.

Another aspect of the exhibition of this class that may be dwelt upon is that the buildings erected, &c., do not impose the restrictions under which ordinary every-day illumination is carried out, while the special nature of the exhibits naturally calls for and deserves a degree of ingenuity in the matter of lighting that would not be bestowed on the contents of an ordinary shop window.

In order to give an idea of the different methods of lighting in use in the grounds of the exhibition we reproduce in Fig. 1 a rough plan of the exhibition in which the systems of lighting adopted in the case of the various portions of the exhibition are diagrammatically indicated. Broadly, we may divide the outside lighting into two sections, that lighted by gas and electricity respectively. Arc-lighting is, of course, largely in evidence, various types of open and enclosed arcs being utilized for the lighting of the avenues, and in some cases for the outside of the buildings also. Thus flame-arcs are used to line the Avenue of Progress and the Stadium Avenue, and also for the lighting of the outside of the Canadian Palace, *The Daily Mail* kiosk, and the Court of Arts, while the space adjoining the Elite Gardens are lighted by enclosed arcs, and the new Jandus enclosed flame arc-lamps are used in the Wood Lane Station. Naturally the traditional system of outline lighting is very generally used for the illumination of the outside of the various buildings, white and coloured glow-lamps being exclusively used for this purpose, and on a scale that is probably unique in this country.

In Fig. 2, for instance, is to be seen a view of the Court of Honour illuminated by night, the lighting being carried out by electric glow lamps. Messrs. Furse & Co., of Nottingham, who are responsible for the illumination of the Court of Honour, inform us that as many as 20,000 lamps are here employed, while over 5,000 are used in the Palace of Music, as shown in Fig. 3. This system of exterior illumination is employed in the case of the majority of the buildings distributed throughout the Exhibition, and it is estimated that well over 100,000 lamps are used for the entire display.

The most recent developments in gas lighting are exemplified in the new Keith high-pressure gas lamps, burning on a gas pressure of 55 to 60 inches, and, though only utilizing a single mantle, stated to yield 1,500 c.-p. each. These lamps are spaced about 50 feet apart, and illuminate the portion of the Exhibition beyond the central, eastern, and western circuses.

It will be remembered that, according to the recent tests of Mr. W. R. Herring (*Illuminating Engineer*, June, 1908), these lamps were found to give 60 to

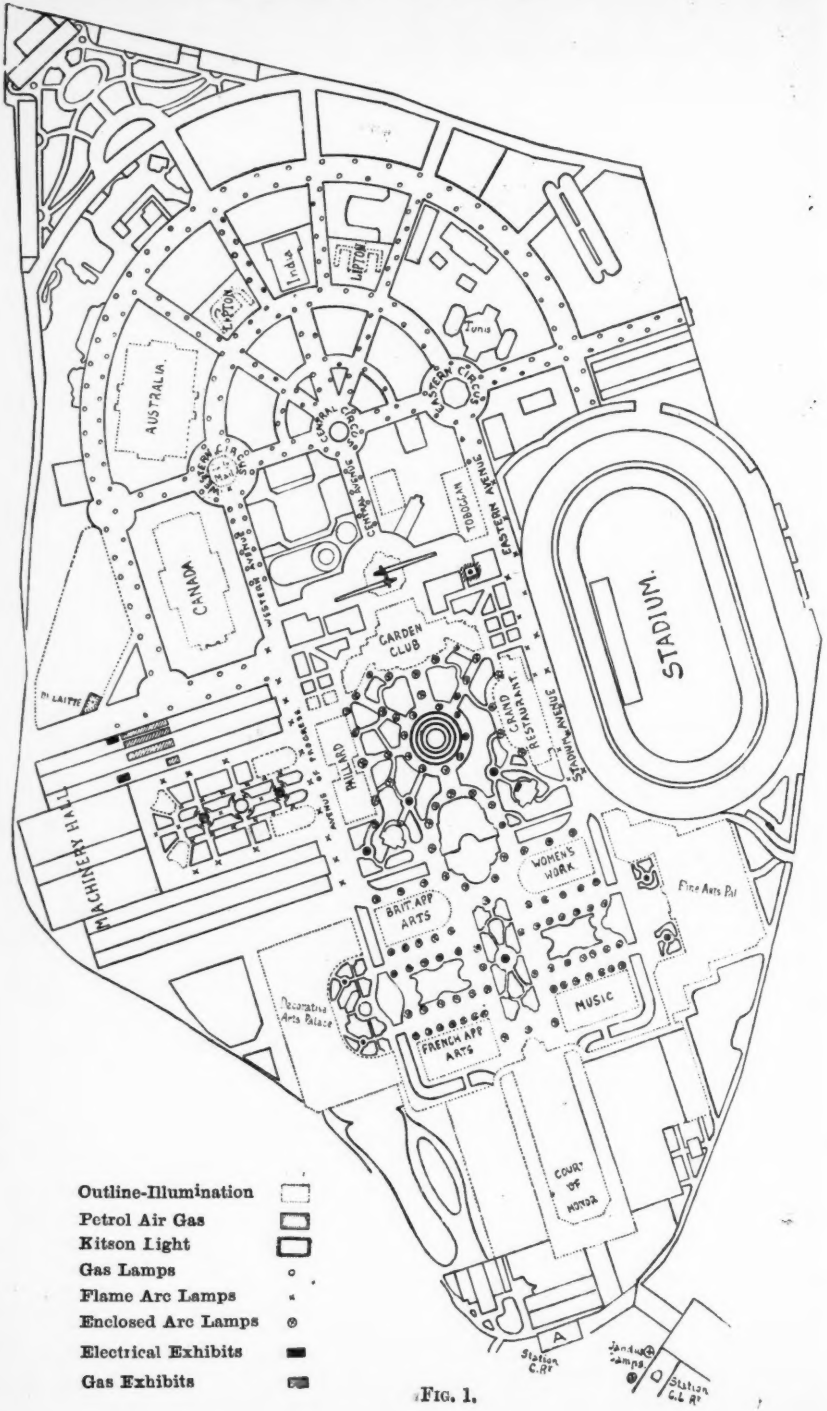

AUSTRALIA
CANADA
INDIA
TUNIS
CENTRAL CIRCUS
EASTERN CIRCUS
EASTERN AVENUE
STADIUM
GARDEN CLUB
GRAND RESTAURANT
MACHINERY HALL
WOMEN'S WORK
BRIT. APP. ARTS
FRENCH APP. ARTS
MUSIC
COURT OF HONOR
Fine Arts Pal
Decorative Arts Palace
Outline-Illumination
Petrol Air Gas
Kitson Light
Gas Lamps
Flame Arc Lamps
Enclosed Arc Lamps
Electrical Exhibits
Gas Exhibits

FIG. 1.

70 candle-power of per cubic foot of gas per hour—a notable advance over anything previously attained. In Fig. 4 is shown a view of the Indian Pavilion and the adjoining grounds so illuminated.

Oil and petrol-air gas incandescent lighting also find representation in the exhibits of the Kitson, the De Laitte, and other exhibits. The variety of the lighting of the grounds of the exhibition, therefore, presents a considerable field for discussion. On the present occasion we do not propose to enter into detailed discussion of the many interesting points in illuminating engineering that suggest themselves, though we hope to deal with certain sections of the exhibit more fully in a subsequent number. In the article that follows, however, will be found some impressions of exhibition lighting in general.

Meanwhile we cannot refrain from commenting upon the striking divergence in the views expressed in different quarters not only as regards matters of detail, but on the fundamental objects and aims of exhibition and spectacular lighting. As an illustration of such sharp contrasts in opinion, mention may be made of the appearance of the Court of Honour. If one were to judge from the general expressions of opinion of visitors to the exhibition, one would no doubt assume the results of the traditional scheme of "outline-lighting" to be in this case eminently satisfactory. Most of those present seemed to feel that the general effect surpassed anything that had been presented to them before, and, indeed, that the general appearance of the Court by night was tasteful and—to use a very generally specified term of approval—"fairy-like." It does not follow, of course, that such a consensus of opinion, even if it could be shown to exist, is final; naturally the public taste in these matters is based solely upon what has previously been presented to them, and the general method of lighting here adopted, is that hitherto almost exclusively employed in exhibitions and on festive occasions generally. The public might, however, be willing to recognize a quite different method as incontestably superior from the æsthetic standpoint, were it presented to them.

On the other hand, we find the same difference of opinion as to the results achieved expressed in the press, and in quarters in which the criteria as to what is good lighting and what is bad are more generally understood and more sharply defined. The same effect is described as a fairyland of beauty in some instances, while in others it is termed glaring and vulgar, and extremely wearisome to the eye. Such extreme diversity of opinion, even if in part attributable to the partiality in favour of the particular system of lighting or the reverse, is still remarkable, and shows that æsthetic illumination is still very debatable ground to many of those in the lighting profession.

Very instructive, too, are the impressions created by passing from one section of the exhibition to an adjacent portion illuminated by some different system. If mere ocular demonstration were to be relied upon in deciding the merits of methods of lighting to be seen side by side, some very conflicting results could be reached. This is well illustrated by the appearance of the adjacent regions of the grounds lighted by flame-arcs and high pressure gas lamps respectively. For one thing the impression of the observer depends very greatly upon whether he stands on the borderland between the two systems, or takes up his position among the lamps lighting one of the two sections. Again, the opinions of many of those visiting the grounds in his company are probably based mainly on the actual apparent brightness of the sources of light themselves rather than upon the ground illumination. Clearly this is quite a different matter to illuminating power. An incandescent gas lamp, for example, naturally tends to appear brighter to any one approaching it from a distance than does an arc-lamp with inclined carbons in which nearly all the light is deliberately projected downwards. It may be urged that for spectacular lighting the apparent brightness of a source seen from a distance is a point to be considered,

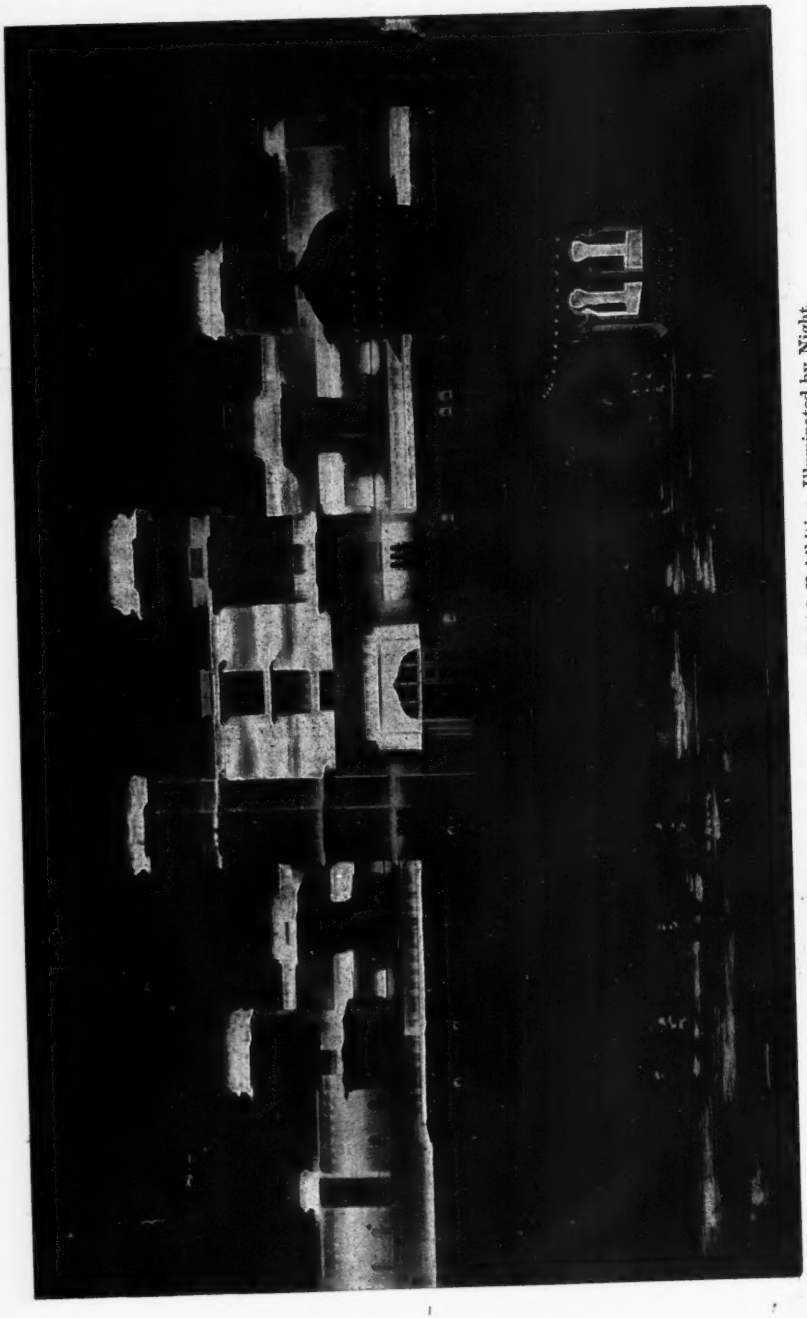


FIG. 2.—The Court of Honour, Franco-British Exhibition, Illuminated by Night.

and an asset of value. This may be possibly the case, but such a use of an illuminant ought to be kept quite distinct from its power of illuminating. We ought to modify the polar curve of distribution of light of a source in such a way as to render it valuable for whichever of these two distinct uses was most important in the particular case to be considered.

Another factor which is not without influence upon the observer is the frame of mind in which he makes his visit. In one case that came before the writer's notice, the effect produced by the lighting of one section of the exhibition was entirely discounted by the glowing account which the visitor had previously received. As often happens in such circumstances,

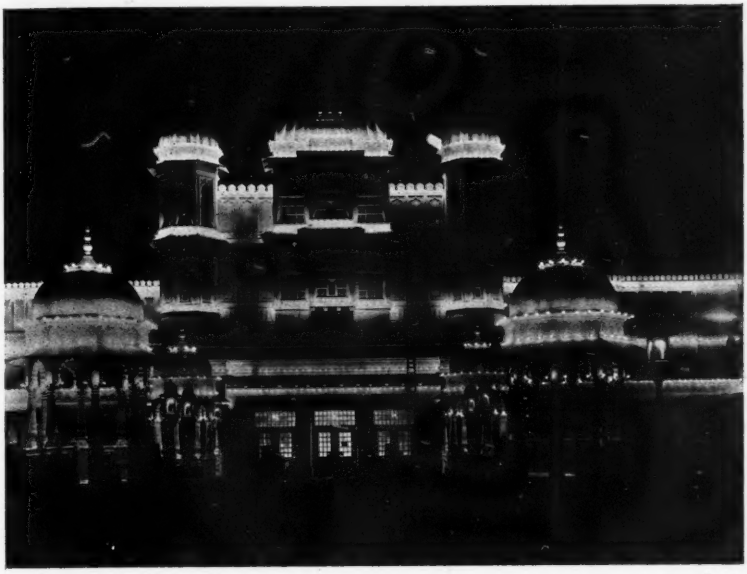


FIG. 3.—Palace of Music, Franco-British Exhibition, Illuminated by Distributed Glow-Lamps.



FIG. 4.—Indian Pavilion, and Adjoining Avenues, Illuminated by High-Pressure Gas.



FIG. 5.—Kitchen



FIG. 6.—Bedroom.

Views of the Electrically-Lighted "Model Home" in the Machinery Hall at the Franco-British Exhibition.

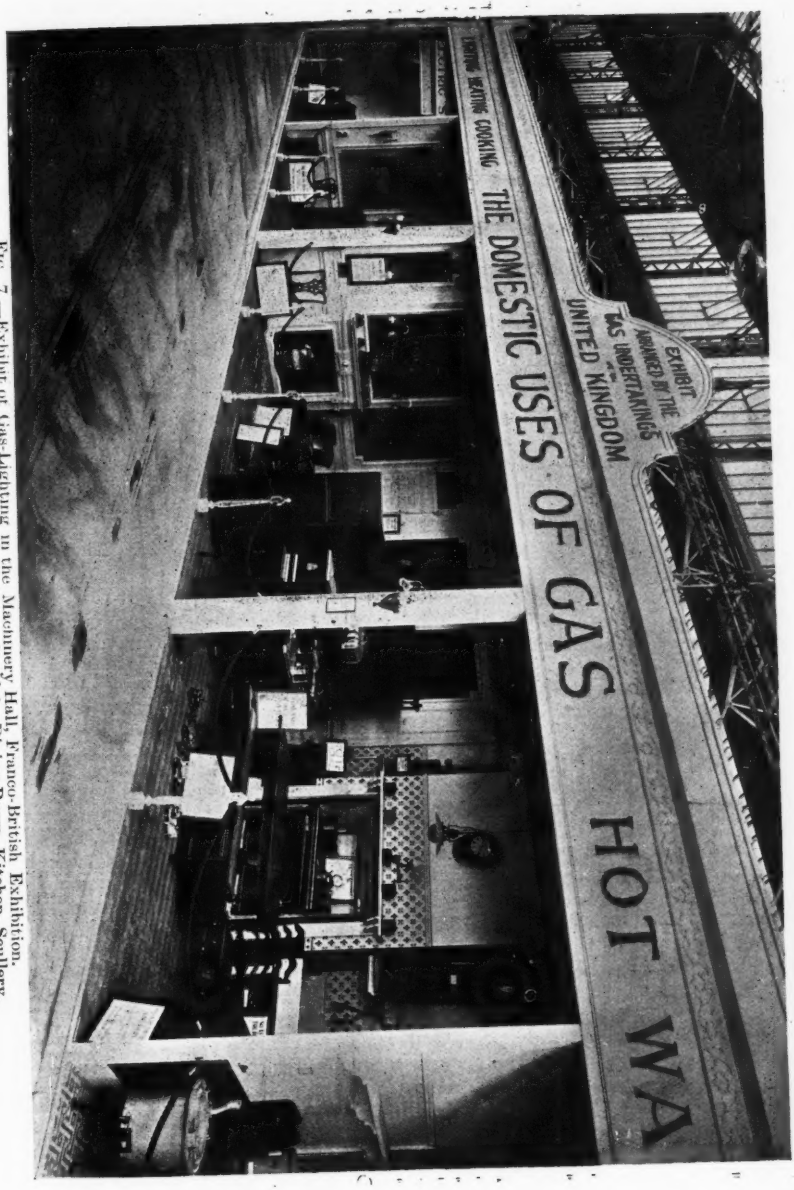


FIG. 7.—Exhibit of Gas-Lighting in the Machinery Hall, Franco-British Exhibition.
From left to right the rooms are:—Billiard Room, Boudoir, Dining Room, Kitchen, Scullery.

he found that the reality did not come up to his expectations, and he departed from the exhibition with a totally opposite impression from that pictured in his state of mind before his visit. Such considerations only serve to make it clear that, although general impressions of this kind ought to be taken into account they cannot serve as a valid system of comparison unless supported by actual tests with instruments which can be referred to a constant standard and are not entirely at the mercy of fluctuating mental impressions.

Among the actual exhibits connected with lighting and illumination, reference may first be made to the exhibition of gas and electric lighting in the Machinery Hall. Here we have the interesting situation of two adjacent sets of rooms, tastefully furnished and got-up with the object of displaying the merits of gas and electric lighting respectively. The electric exhibit takes the form of a model house, entirely illuminated within by electricity and completely furnished by Messrs. Waring & Gillow. Through the series of rooms ranging from the drawing and dining room to the kitchen the visitors make a circular tour, and are given an opportunity of seeing a number of different lighting fixtures employing both direct and indirect diffused illumination.

Heating and cooking also receive attention. The visitor finds electrically heated hair-curlers, bed-warmers, &c., in the bedrooms, demonstrations in cooking in progress in the kitchen, and ventilating fans blowing a small gale as he passes from one room to the other.

The furnishing of the house is stated to cost £200, and the cost of electric lighting is given as £6 a year. Needless to say placards emphasizing the merits of electric lighting are duly presented to the notice of all entering or leaving the house, and make interesting reading for those who linger to peruse them.

Immediately adjacent to the electrical exhibit the visitor has an opportunity of learning what gas has to say for itself, and if he occasionally finds the contents of the notices commending its use somewhat unsettling, if not a positive shock, after the impression derived from the notices next door, he will not fail to be interested in the attractive suite of rooms, some of which are shown in Fig. 7. In this case, it will be seen, the gas exhibitors have elected to use an open form of room, readily available to the public.

In the suite of rooms which include drawing-room, library, two bedrooms, bathroom, nursery, billiard room, boudoir, dining-room, kitchen, scullery, and laundry, a number of different types of burners, both upright and inverted, are to be seen, while the laundry is illuminated by Keith high-pressure lights. Some of the 1500 candle-power lights likewise serve to advertise the whereabouts of the display, flame arc-lamps performing a similar function for the electrical display. The display is brought thoroughly up-to-date by the instalment of several types of pneumatic distance-lighting apparatus, by the aid of which any light may be turned on at will by merely turning a switch. Needless to say cooking and heating by gas are to be found in evidence in all the rooms, especially in the kitchen and laundry; it is also interesting to note that the dining-room contains an electrically operated pianola supplied with electricity generated by the adjacent compressor plant.

It is curious to observe that the usual positions of gas and electric lighting are in this case, to some extent, reversed. In the past it has frequently been contended that gas was the cheaper, but that electricity offered special conveniences that commended its adoption to the man to whom expense was of relatively small importance. In the present instance, however, the main object of the gas exhibit appears to be to show that gas-lighting is acceptable even when utilized to illuminate costly and luxurious surroundings, while the electrical exhibit is intended to illustrate the fact that artistic electric lighting is open to those of very modest means.

Yet another illustration of indoor-lighting is afforded by the exhibit of the De Laitte Petrol-Air Gas Co., which, however, is not in the Machinery

Hall, but occupies a separate position in the grounds of the exhibition near the Scenic Railway. The exhibit consists of an easily accessible demonstration of the automatic apparatus for generating the gas, and a series of tastefully got-up rooms illuminated by various types of fixtures from the gas generated outside in the open air.

In Fig. 8 we reproduce a photograph of one of these rooms.

The central inverted fixture is exceptionally attractive. The demonstration of the working of the system, in which the automatic process of generation is set in motion by a weight which afterwards slowly descends as the gas is used up and has to be replaced in the reservoir, is calculated to give the impression that the generating apparatus is exceedingly simple to operate.

Other examples of petrol-air gas illumination are furnished by the exhibit of the Pitner Invetrol Lighting Co. and the Oetzmann Country Home lighted by the Cox air-gas system.

Those visiting the exhibition have, therefore, ample opportunity to study the claims of different illuminants, and if they occasionally find themselves confronted by apparently conflicting statements, put forward side by side, this only serves to show the difficulty of obtaining reliable information on all illuminants, and the necessity for expert and impartial outside judgment.



FIG. 8.—Room Illuminated by Petrol-Air Gas. The De Laitte Model Installation, Franco-British Exhibition.

Naturally there are many other features in the Exhibition of considerable interest to the illuminating engineer. The special efforts made in the present instance serve to give an idea of the immense field for enterprise in the employment of the principles of illuminating engineering in order to secure the special spectacular and attractive effects. An exhibition of this kind presents endless opportunities of using light in such a way as to at-

tract the attention of passers-by to certain exhibits, and also of showing them off to the best advantage. This is the more true, because the importance of the occasion justifies the exhibitor in expending an amount of money and thought that would be grudged under ordinary circumstances.

One feature that is especially prominent in the present Exhibition is the predominance of scenic effects, usually accentuated by special illumination. For instance, we encounter a striking example of such a scene in the effective illuminated pictures representing the vineyards of the Gilbey Distilleries at the very entrance to the Court of Honour.

Other, perhaps, even more interesting efforts in this direction are to be seen in the Canadian exhibit. Here are a number of beautiful and striking tableaux explaining certain aspects of Canadian life and industries. A specially interesting feature of this exhibit is the frequent use of transmitted light to illuminate scenery and portraits, &c. Naturally this method can be utilized to make certain objects stand out and attract the eye in a way that could hardly be secured otherwise.

In the present instance, however, one feels that the high general illumination from the flame arcs used to illuminate the interior of this building, excellent as it may be considered to be from an ordinary practical standpoint, rather weakens the effect of all but the brightest of the transparencies, and that a higher local illumination could be profitably employed in some cases. Nevertheless, the general nature of the scheme in this hall constitutes an important development in scenic exhibition lighting, and in a very legitimate and desirable direction.

Needless to say, countless interesting problems in shop-window lighting are to be found. Some excellent examples occur to the left of the Court of Honour on entry, where a number of the latest Parisian fashions are displayed.

In one case an effective display is obtained by concealing the glow-lamps behind linen bands, and using others as foot-lights. The general effect is, at any rate, much more in accordance with sound principles of illumination than much of the window-lighting we see in the streets of London, though it is quite possible that the same results might be obtained more cheaply if necessary by the use of more effective reflecting devices.

Among the examples of special illuminating devices for attracting attention may be mentioned that in use in the exhibit of one of the tobacconists. A number of tins of the standard type are piled up in the window, and all to the eye look alike. Some of the tins, however, are really made of semi-transparent material, and contain a glow-lamp. By means of a mechanically-operated switch certain tins are caused to appear brightly illuminated at different intervals, and then to relapse into comparative darkness and to resemble their companions.

A few of the exhibits in the Science Section merit special notice. Sir Joseph Swan has contributed an exhibit of early forms of glow-lamps, including one that is said to be the first actually exhibited in public in this country.

The National Physical Laboratory exhibit a series of large bulb Fleming-Ediswan standard glow-lamps, and an arrangement used by Mr. Patterson to secure that all of a number of glow-lamps undergoing a life-test shall burn at exactly the same watts per candle-power.

There are also some interesting particulars of coloured gelatine films supplied to the laboratory by Messrs. Watton & Wainright, including curves illustrating the percentage of light transmitted throughout the spectrum in each case.

Finally, we wish to express our indebtedness to the De Laitte Petrol-Air Gas Co., Messrs. Waring & Gillow, *The Gas World*, and *The World's Work*, for the use of some of the blocks and photographs employed in this article.

The Lighting of the Grounds and Buildings of Exhibitions, &c., with Special Reference to the Franco-British Exhibition.

By an Engineering Correspondent.

One of the most interesting aspects of the lighting of an exhibition from the standpoint of an illuminating engineer is certainly the problem of producing attractive effects in the grounds—"landscape-illumination" one might almost term it.

The possibilities of securing specially successful results in this direction depend very greatly on the variety of the buildings distributed about the grounds, and upon the method of illuminating them. In almost all cases in which illumination has been used for spectacular effects of this kind in the past the method of "outline-lighting" has been adopted. It may, indeed, be said that this method of lighting has almost become a tradition.

Outline-lighting consists essentially in so distributing glow-lamps as to follow the lines of a building, and so to sketch its outlines in a luminous form. Regarded from the pictorial standpoint, therefore, in genuine outline lighting, we approximate to the efforts of the artist or the draughtsman when he sketches an object in outline merely. By this method, therefore, we may hope, perhaps, to preserve the beauty of line of a building, but we cannot hope easily to reproduce the alternation of light and shade which play a great part in the appearance of all buildings having any claims to architectural distinction. In such a case as the Franco-British Exhibition, in which buildings of admitted beauty from the architectural standpoint have been put up, the illumination of the buildings by night becomes an important consideration.

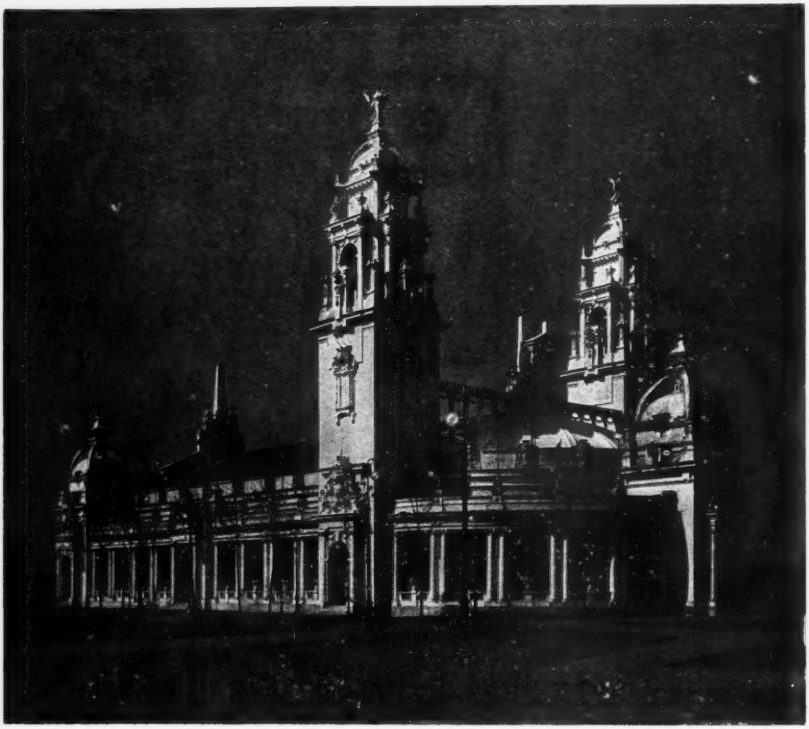
In the Franco-British Exhibition, however, the traditional method of outline-lighting has been followed almost throughout, and a few of the buildings which are not yet illuminated in this way appear to be about to be treated in the same way as the others.

Strange to say, the opinions that have been expressed on this point differ very greatly. Many people seem to regard this method of lighting as the natural and ultimate goal of exhibition-lighting. Others consider the multiplication of small bright sources only bewildering and trying to the eyes. The writer feels obliged to confess that, up to a certain point, he shares the latter impression. The effect of small but very bright sources on the eye is too well known to require elaboration. In the case of large buildings the effect is lessened by the comparatively great distance of the lamps from the eye. Moreover, in the case of the very white buildings used in the exhibition we see not only the filaments of the glow-lamps themselves, but also a vast amount of reflected light. This reflected light enables us to see the form of the building as a whole, and the moderate general illumination to which this circumstance gives rise helps to tone down the otherwise disagreeably bright outline-lighting. The value of the Court of Honour as a decoration by night would seem to be attributable as much to this reflected light as to the outline-effect. Even so the author personally finds the multiplication of small bright spots of light objectionable.

As has been suggested above, outline-lighting depicts the lines of a building. In cases in which the lamps are merely strung about a building haphazard, without respect to its true outline and projections, it loses even this value; but in any case the effect is impaired from an artistic point of view, by our being compelled to draw such bright, disjointed spotty lines. Possibly the use of such a source as the Moore tube might lead to the artistic possibilities of this method being greatly extended.

We see, however, that if we really

wish to show off the features of a building as it appears by daylight, line-lighting is ineffectual. It is true that the building does receive a certain amount of general diffused lighting by this means; yet this light strikes the faces of the building in a haphazard manner, and cannot be expected to bring out the shadows of artistic mouldings and projections as they appear in daylight. To illustrate this point of view observe the appearance of the British Palace of Applied Arts, as shown in Fig. 1.



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FIG. 1.—British Palace of Applied Arts, Franco-British Exhibition.

The light falls upon the building from a certain angle, bringing out all its lines, projections, and depressions, and the effect is pleasing. Moreover, the general effect depends upon broad masses of light and shadow—there is no wearisome speckly pattern of light and shade and no glare. The author would therefore suggest that this is the condition of things which we ought to imitate by means of artificial light rather than the previous method of outline effects.

This view appears the more reasonable because the white surface of the buildings erected in the Franco-British Exhibition are singularly favourable to illumination from without. As it is, the amount of diffused light about the exhibition is quite exceptionally great compared with outside street conditions, while in sunlight the reflected light is sometimes so strong as to be distressing to many people.

Another example of the attempted use of artificial light in the desired direction is presented by Fig. 2, which is taken from a photograph of the lighting at the Düsseldorf Industrial Exhibition of 1902.

In this case the white exteriors of the buildings are illuminated by arc-lamps of the Regina type, by the Regina Arc-Lamp Co., of Cöln-Sülz. Fig. 2 is interesting on account of the fact that it illustrates an attempt to specially illuminate a fresco on the outside of the building.

While it cannot be contended that the particular case cited above represents the best that could possibly be done in this way, the author personally very greatly prefers even the comparatively simple method which it represents to the wearisome outline-lighting effects. There is, however, no reason why we should confine ourselves to the use of sources of light on the tops of long posts, &c., in order to produce the pleasant diffused lighting referred to. The real essentials of the method are that we should see broad masses of illuminated surface rather than concentrated bright points. An absolute uniform illumination is obviously undesirable on æsthetic grounds, but it is easy to avoid this result; it would, indeed, be far from easy to produce it, though it may be pointed out that, in the case of outline lighting with glow-lamps, we approach it, owing to the distribution of light over the entire white surface.

Probably the most effective results are to be secured by hiding the lamp behind some projection on the face of the building, so that the surfaces illuminated by it are visible, but not the light itself. An attempt in this direction seems to be made in the case of the Palace of Women's Work, where arc-lamps are suspended beneath the open domes of the towers, so as to illuminate the adjacent surfaces and produce an interesting play of shadow, without themselves offending the eye. An effort in the same direction is made in the Indian Pavilion, where the gas-lamps suspended under the domes of each of the towers play the same part as the arc-lamps in the case just mentioned.

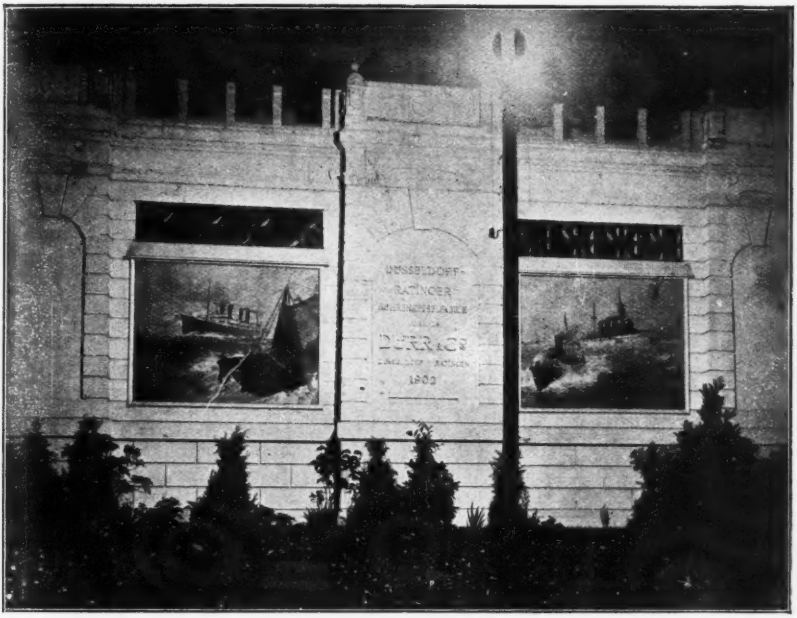


FIG. 2.—Illumination of Pictures on outside of Exhibition-Building (Düsseldorf Industrial Exhibition, 1902).

The open corridors surrounding some of the palaces at the exhibition also offer very great possibilities of illumination in this way. For instance, the covered walk seen in Fig. 3 might be illuminated by lamps placed on the ceiling and invisible to those outside. As a matter of fact in a number of cases very pleasing effects are produced involuntarily in this very manner. Some of the flame arc-lamps surrounding the Canadian Palace are cases in sources themselves when they are too intrinsically brilliant to be pleasant to the eye.

Just in the same way that sources of light are often mainly used to enable us to see the architectural features of buildings by night, so the sources used in the grounds are meant primarily to enable us to see our way about. Therefore we ought also to try and secure that the brilliancy of such sources is never sufficient to dazzle the eye



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FIG. 3.—Corridor, looking out on Court of Honour, at the Franco-British Exhibition.

point; one frequently gets a charming glimpse of some portion of the building lighted up brighter than the rest, without the source itself being apparent.

In short it seems reasonable to conclude that our main object in attaching lights to the exteriors of buildings of artistic and architectural value should be to exhibit its architectural characteristics in the same manner as occurs in daylight-illumination, and to try to conceal, as far as possible, the when looking about. It is well known that in ordinary street-lighting it is almost impossible to secure the exact theoretical conditions, because there is no evident method of using lights to effectually illuminate the ground and yet to be invariably out of the line of sight of the pedestrian. The most we can do is to provide such sources with suitable diffusing shades so as to modify their brilliancy. Even so, it is probable that they will be

inconvenient when the observer wishes to make out something in the background behind them.

It must also be remembered that the attention is involuntarily attracted by such bright patches of light. If we desire to draw general attention to a certain building or a stall we ought to make the local illumination in this neighbourhood higher than that of the surroundings. The illuminated kiosk in Fig. 4 is an illustration of what is legitimate in this way. The illumination due to the concealed lights is satisfactory, not only because it attracts attention to the correct point, but also because this method lends itself to artistic treatment.

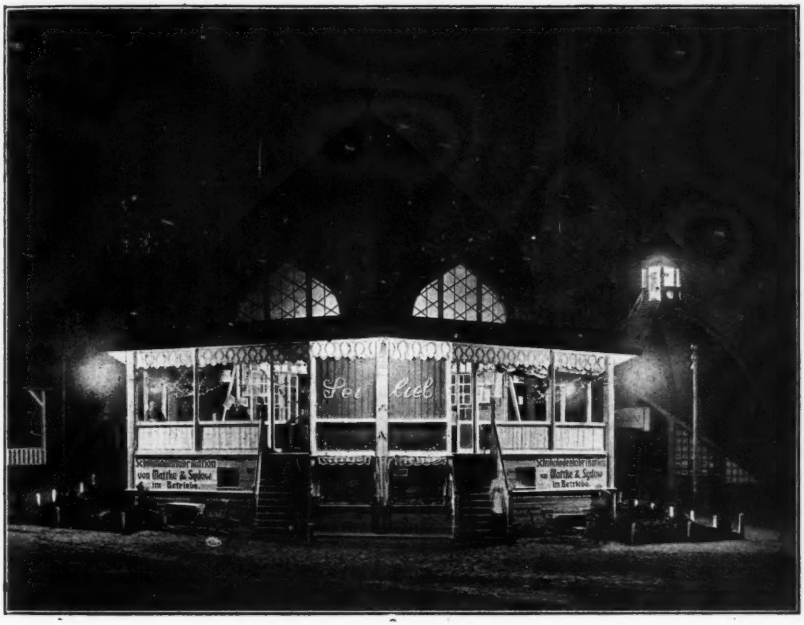


FIG. 4.—Mattke & Sidow Pavillion (Görlitz Industrial Exhibition, Saxony). Lighted by "Regina" enclosed 5 amp. arcs.

At the White City the conditions are exceptionally favourable on account of the excellent reflecting character of the buildings and the large amount of general diffused illumination to which they give rise. Nevertheless it will probably be admitted by any one impressed with the dilemma referred to above that the lighting in the grounds has not escaped the common difficulty peculiar to all external lighting. The general illumination in the section of the exhibition lighted by gas, for instance, is unquestionably excellent in many ways, but one's approval of the performance of the high-pressure gas-lights is modified by a feeling that their great brilliancy becomes very inconvenient when one attempts to examine any object in their immediate neighbourhood. This feeling is probably intensified by the fact that the lamps seem to be placed exceptionally low considering their high candle-power. The same remarks apply to a greater or less degree to the general illumination by arc-lights.

Apart from the value of illumination for the purposes already referred to, one might suppose that there is scope for considerably more originality and ingenuity in devising methods of showing off certain features of the grounds

or calling attention to certain objects. One is inclined to think that more might be done in the way of illuminating the tastefully arranged flower-beds in the gardens of the exhibition, for instance. In the daytime these are prominent objects, but in the night time they fail to receive the same attention, owing to the fact that they are illuminated so comparatively feebly. It is true that in one place in the Elite Gardens an attempt is now being made to surround the beds with a string of naked glow-lamps. But naked glow-lamps, whatever be their merits for other purposes, are not in themselves beautiful objects, especially at close range, and this continuation of the principle of outline lighting seems to the author in this instance particularly out of place. It would seem to be a greatly preferable plan to try to throw the light on to the beds from shaded lights, invisible to the observer, as is done on the stage. The same remarks apply to statuettes and other objects that are considered decorative in the daytime, but whose existence seems to be often disregarded by night.

Needless to say there are also great possibilities in the way of creating special colour-effects, &c., which artificial light enables us to do with comparative success. Practically the only example of the deliberate use of coloured light in this way, apart from the coloured glow-lamps outlining the buildings, lies in the illuminated cascade in the Court of Honour. The author, however, is inclined to suppose that the principle on which this illumination is contrived is incorrect. This cascade, it will be remembered, makes its way over a series of glass steps, illuminated from behind by means of transmitted light. As a matter of fact, the light in this case seems irregularly distributed, for only certain persons looking in a certain direction receive the full benefit of the coloured light coming through the water. Apart from any defects in the distribution of the light, however, it may be doubted whether running water can be very effectually illuminated by transmitted light at all. Certainly it will be observed that the charm of the cascade in the Court of Honour depends mainly on the light reflected to the eye from the flowing water, and the most striking effects in the way of fountain-illumination, &c., have, according to the writer's experience, always been obtained by means of reflected light.

Immense possibilities in the decorative way seem to lie in the illumination of the white buildings of an exhibition by means of coloured light, in such a way as to light up adjacent portions with harmonious shades of colour. Some of the most pleasing effects (in the writer's opinion once more) are produced in this very way. For instance, in several cases the outside of the building receives light of a bluish character from the enclosed arcs without, while sheltered flame arcs light up the porches and porticos and other portions of the interior of the building with a soft yellow light. In the Court of Honour, too, there are several cases in which an effect of this kind has been obtained, apparently without design, by the use of lights differing in colour from those of the surrounding illumination.

In throwing out the suggestions in this article the writer is conscious that to many they may appear impracticable, or even undesirable. He himself is convinced that there is an immense field for the application of artificial light to the production of spectacular effects, and especially to the illumination of the exteriors of buildings.

It is, at least, evident that if a building has any artistic pretensions at all, the method of illuminating its exterior ought to receive careful consideration both from the architect and the lighting engineer, so that its attractive features may be shown off to the best advantage. The dirtiness of most street buildings and the other considerations connected with traffic, &c., impose limitations under ordinary conditions which do not exist in the case of an exhibition. Even so, however, there cannot be much doubt that very much more might be done under proper artistic direction in this matter, even in the streets of London.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

Liquid Gas.

(From the *Illustrierte Technische Umschau*, Zürich, June 20th.)

Coal-gas, which can be used with such advantage in towns on account of the density of the supply area, cannot be employed in the country, as the consumption would bear no adequate comparison to the extent of the necessary mains. Electric light is too dear to permit its general introduction in all classes of society. Like its competitor, coal-gas, it can only be used in exceptional cases at a great distance from the source of supply. Lighting by petroleum, on the other hand, no longer satisfactorily meets the requirements of modern life, and consequently the demand for light is continually increasing. All this explains why, for a long time past, a lighting medium has been sought which should be at the same time practical, artistic, and economical, and serve for the lighting of residences which are situated at a distance from central sources of supply, and for villas, factories, country houses, hotels, &c., as well as for railway carriages, automobiles, &c.

The use of electric furnaces, which permit the manufacture on a large scale of calcium carbide, seemed, at least for a short time, to ensure a brilliant future for acetylene gas, especially as this gas can be transformed in a fairly simple manner into the liquid state, and it was thought that the important problem of obtaining a transportable lighting gas had been solved. Unfortunately, owing to the extraordinary explosiveness of this gas, especially in the liquid state, these hopes were quickly doomed to disappointment, the more so as in most towns liquid acetylene is classed as an explosive, and this regulation extends to the gas even when compressed to a few atmospheres' pressure.

The result of this regulation has been that at present, in order to utilize acetylene gas for lighting purposes, recourse has had to be made to private installations for the production of the gas.

These installations are, as is well known, complicated and very delicate, and danger is not entirely removed in this way. The problem of obtaining a transportable lighting gas, therefore, still remained unsolved.

A striking proof of the importance of this question is found in the great activity of all makers of the various apparatus for the production of air, alcohol, benzine, petroleum, and gasoline gases, &c. They all pursue the same object—to furnish isolated residences with their own supply of lighting gas; but none has succeeded in overcoming the general objection, viz., the preparation of the gas in the house itself.

Only after tedious research has Herr Wolf succeeded, *by a simple, convenient, and cheap process*, in producing what he terms "liquid gas." In liquid gas we have at last a product which no longer necessitates any producing-apparatus in the house, which is not poisonous, is less explosive than town-lighting gas, and possesses the maximum lighting and heating power.

Liquid gas is a gas obtained by the distillation in retorts of various raw materials, such as heavy oils, paraffin oils, raw petroleum, and all its products and residues. This gas is afterwards transferred into the liquid state by means of a special process, which forms the object of the patented invention, rendering possible its transport in steel cylinders to any required distance.

The following extracts from an analytical report of Prof. Bunte's laboratory in Carlsruhe, August, 1907, explain the composition and properties of this gas:—

"The 'liquid gas' is a mixture of carbo-hydrates which is gaseous at the ordinary air-pressure. When highly compressed the gas is liquefied, and is supplied in this state, the same as carbonic acid gas, in strong steel cylinders. When in use it is allowed to flow out of the cylinder, and by the decrease of pressure again assumes the gaseous form. After passing through suitable pressure reducing and regulating apparatus, it

flows through the distributing pipes to the point where required, when it is used like coal-gas.

"The gas consists principally of ethylene and ethane, together with small quantities of methane and higher homologues of ethane and a little benzole.

"The specific gravity compared to air is 1·027, so that the average molecular weight of the gas corresponds almost exactly to that of ethane.

"The heating value per cubic meter of gas at 0° and 760 mm. pressure was determined as 15·595 T.U. It is therefore three times as great as ordinary coal-gas.

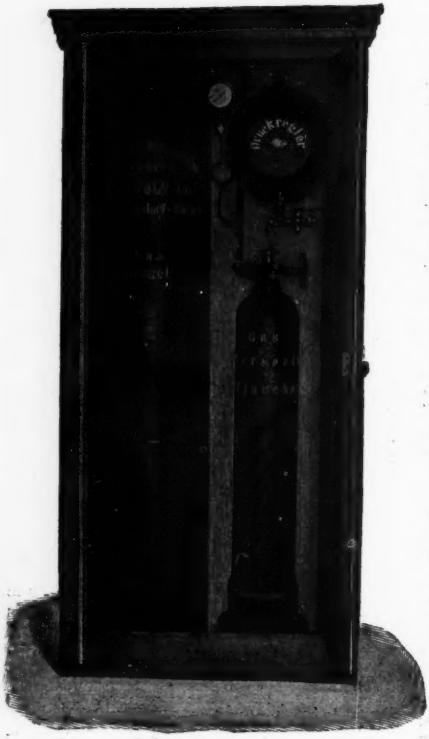


FIG. 1.

"By the use of an incandescent gas burner suitably arranged for this gas, with 85 mm. pressure of gas and a consumption of 28·5 litres per hour, an average horizontal lighting effect of 75 Hefner candles was obtained. In this test the volume of the gas was measured wet at 760 mm. pressure and 18°C. This corresponds to 26·1 litres of dry gas as 0°C. and 760 mm. pressure. This gives a consumption of 0·35 *litres of gas at* 0°C. *and* 760 *mm. pressure per Hefner candle-power-hour.*"

The gas, therefore, has a very high lighting and heating coefficient; it is moreover, free from carbonic oxide, and for this reason not dangerous. Its explosiveness is 13 *times less than that of acetylene, and* 3 *times less than that of coal-gas.*

The transport of this gas presents absolutely no difficulty. For instance, in Switzerland it is treated by the railways the same as liquid carbonic acid.

Figs. 1 and 2 will give an idea of the usual storing apparatus.

Its use is extremely simple, the whole installation for a house only taking up the space of a cupboard. This contains the entire apparatus, consisting of the steel cylinder with the liquid gas, and a small gasometer connected thereto. This cupboard, made of wood or metal plates, can also be situated outside the house, *as the liquid gas is not influenced in any way by the outside temperature.* The piping passes from the gasometer; such pipes are of very small diameter. If they already exist, the ordinary gas-pipes may be utilized.

This means, therefore, no more generators in the house, no more cleaning and drying of the gas, as in an acetylene plant, no more waste products of manufacture, and no more mechanical parts, motors, and counter-weight, as in gasifying plants.

In the lighting of carriages it accomplishes a great simplification as compared, for instance, with lighting by oil gas. No producing-houses are spaced along the line; no tank-carriages for carrying supplies; no reservoir under each carriage, taking up a great deal of space; a single apparatus, with its steel cylinder, which can be replaced immediately, even whilst running, suffices.

Figs. 3 and 4 are examples of convenient lighting-fixtures.

Liquid gas, however, not only possesses these exceptional properties for lighting, but is particularly suited, on account of its high heating value, for the heating of residences, cooking and ironing, as also for all forms of soldering, from plumbers' work to the autogene welding of metals requiring the highest temperatures.

This last application is at the present time of the utmost importance in the metal industry, where it is on the point of replacing the tedious and lengthy process of riveting.

It is interesting to consider the various processes which are employed to produce the necessary temperature for these operations. Electrical welding, although a temperature of about 3,000 degrees is obtained therein, cannot be used in practice, as the metal welded or soldered by this means becomes too brittle, its structure being altered by a form of crystallization.

Goldschmidt's alumino-thermal process certainly offers great advantages, but not only is it very dear, but its use is also extremely limited, as, however

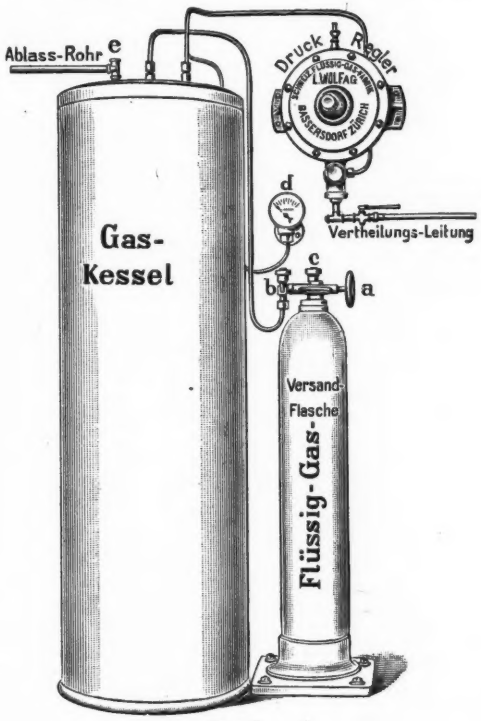


FIG. 2.

useful it may be for welding similarly shaped pieces, such as bars, tubes, &c., it is not practical for boiler-making and the repair of various parts. There remain therefore the two processes utilizing oxygen and hydrogen, and oxygen and acetylene respectively.

The oxy-hydrogen flame, which was for a long time almost exclusively used, has been replaced somewhat rapidly by the oxy-acetylene flame, and this for the following reasons :—

1. It is more expensive.

2. It is liable to produce oxidation of the metal.

3. It does not produce a sufficiently high temperature.

Furthermore, hydrogen is not only extremely explosive—a property it shares with acetylene—but is very poisonous to the human organism, as it decomposes the blood, and this property is the more dangerous because the gas has no smell, which would permit of an escape being detected.

As regards practical properties, it may be said that the oxy-hydrogen flame does not produce nearly as high a temperature as that obtained by the use of the oxy-acetylene process.

Fig. 5 shows an arrangement for welding by liquid gas.

As a matter of fact a cubic meter of hydrogen only gives out on burning 2,570 T.U., whilst the same volume of acetylene gives almost 13,000 T.U.

Furthermore the hydrogen flame is very wide, and for this reason the heat is very distributed. This results in a considerable loss of heat by radiation

and a slower action at the welding point.

The oxy-acetylene flame, on the other hand, is short and pointed, and a very small cone may be observed in the centre, the temperature of which is estimated at about 3,500°, whilst that of the oxy-hydrogen flame does not exceed 2,600°. And if it is borne in mind that a *cubic meter of liquid gas developes* 15,500 *T.U., that is* 2,500 *T.U. more than acetylene; that this gas is very easily transportable* (compared with the acetylene generator, the whole apparatus, including the oxygen vessel, takes up but little space), it will be readily understood that by the mixture of oxygen and liquid gas, an ideal flame for autogene welding is obtained, by the use of which greater thicknesses can be welded with a simultaneous saving in both time and gas.



FIG. 3.



FIG. 4.

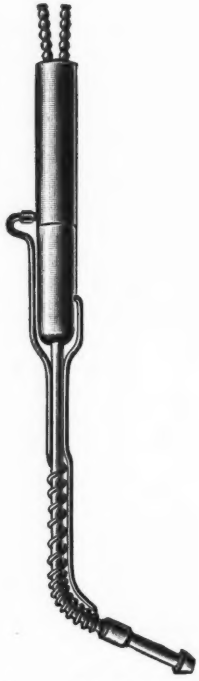


FIG. 5.

Comparison of the cost of various systems of lighting per 100 *Hefner candle-power hours :—*

Petroleum, according to burner used	10-12
Alcohol, according to burner used	8
Acetylene	7-9
Coal-gas	4·5
Liquid gas	6·5

Daylight and Artificial Light.

By Dr. E. L. Nichols.

(Read before the New York Section of the Illuminating Engineering Society, on May 14th, 1908. See the *Transactions* for May, 1908.)

In his interesting and valuable paper on the above subject, Dr. Nichols remarks that there is a general impression that daylight-illumination is the best of all varieties, and that claims on behalf of artificial illuminants are frequently based on their supposed resemblance to natural daylight conditions. Dr. Nichols therefore proceeds to consider in what exactly natural daylight consists, and exactly to what extent it is resembled by ordinary illuminants.

Daylight, of course, is derived from the sun's rays after their passage through the intervening atmosphere of the earth,

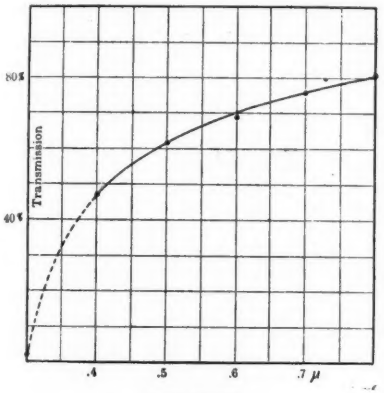


Fig. 1.

and its composition is therefore considerably modified by the depth of air through which this light passes and its varying turbidity, owing to the presence of varying degrees of moisture or of minute particles of dust, &c. The absorption of the atmosphere also affects different regions of the spectrum unequally.

Thus Fig. 1 represents the average transmission of light of different wave-lengths through the earth's atmosphere, as determined by the records, extending over six months, of the Astrophysical Observatory of the Smithsonian Institute.

It will be seen that the violet end of the sun's spectrum is reduced to a greater extent than in the case of the rays of greater wave-length, while the ultra-violet element is known to be affected still more strongly. We now know, for instance, that the inflammation of the eyes which occurs in high altitudes is to be attributed to the action of these rays.

Thus it comes about that daylight under different conditions and in different countries varies considerably both in intensity and in spectral composition. Diffused daylight again differs from

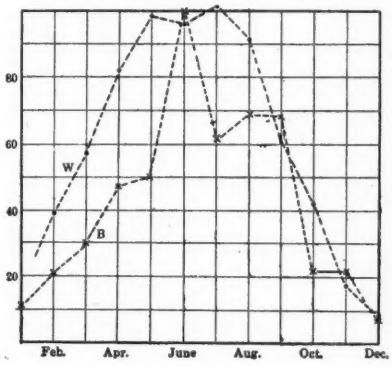


Fig. 2.

direct sunlight, especially as regards the blue and violet constituent. Table I. shows the result of comparing daylight in different localities with the acetylene flame.

In Fig. 2 are also shown some results obtained for the mean annual variation in the intensity of sunlight by L. Weber of Kiel in Germany, and Prof. Basquin of Chicago in the United States. These are marked "W" and "B" respectively. According to Weber the average illumination of the entire sky in July reaches about 100,000 hefner-metres. Dr. Vogel, under the same conditions, obtained 78,000 units.

In Fig. 3, which represents the variation in intensity during the normal day, are shown some results obtained by the author (N) in the Tyrol and Prof. Basquin in Chicago.

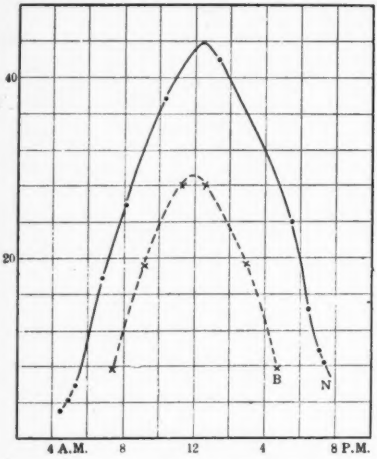
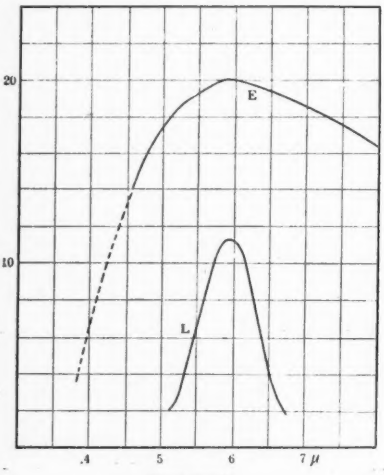


FIG. 3.



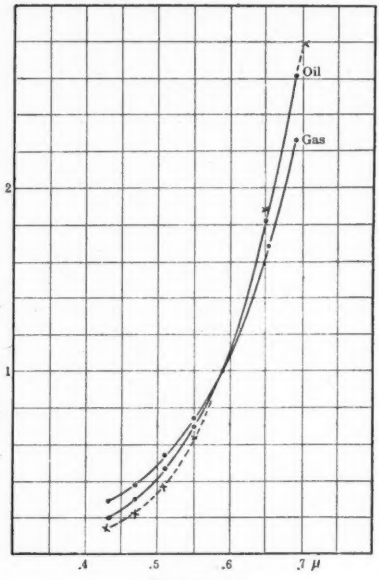
Wave-length.

E. Energy.

L. Luminous Intensity.

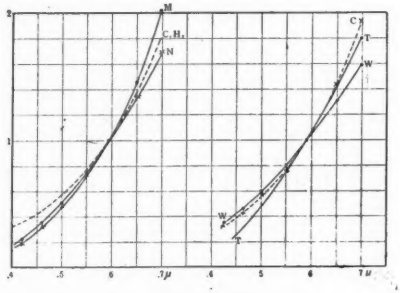
FIG. 4.

We see, therefore, that daylight conditions may vary considerably, but yet the general impression that daylight is physiologically the best of all illuminants has a logical scientific basis, for the eye has actually been developed through countless generations so as to utilize daylight to the best advantage. An interesting illustration of this fact is presented in Fig. 4, where it will be seen that the maximum of the energy-curve



Wave-length.

FIG. 5.



Wave-length.

FIG. 6.

of the solar spectrum E, and the curve of luminous intensity L, occur in exactly the same position, near $\lambda = 0{\cdot}58\mu$. This suggests that the eye has developed itself so as to be most sensitive to yellow light, simply because the energy happens to be mainly concentrated in this particular region of the solar spectrum.

In the second part of his paper Dr. Nichols takes up the comparison of artificial illuminants with daylight. In doing so he divides illuminants into three broad classes :—

1. Those which owe their luminosity to incandescent carbon.
2. Those in which the light-source consists of incandescent oxides.
3. Those in which the spectrum consists of isolated groups of bright lines.

The spectra of the majority of illuminants occurring in Class I. resemble each other fairly closely. Thus in Fig. 5 is shown a comparison between an ordinary flat-flame petroleum lamp and a gas-flame (Sugg standard burner) compared with the Hefner flame.

In Fig. 6 are shown the similar results for the tantalum (T), Nernst (N), and metallised carbon (M) lamps, all of which do not differ very greatly from that of the carbon filament, bearing, however, a closer resemblance to acetylene. It is probable that such differences as occur are not to be ascribed entirely to difference in temperature of incandescence, but also to a small extent to selective radiation.

Fig. 7 shows a comparison between the distribution of intensity in the spectra of the Hefner lamp and sunlight.

In Class II. we include such sources of light as the incandescent mantle, the Nernst filament and the magnesium light, in all of which there is evidence of selective radiation.

The quality of light from incandescent mantles, for instance, depends very greatly on their composition. The earlier mantles were very weak in the red, and showed marked selective radiation near $\lambda = 0{\cdot}65\mu$, as shown in Fig. 8. A newer mantle, of American make, measured one hour after incandescence, gave the results shown in the X curve in Fig. 8. Here the presence of selective radiation is much less noticeable. The change in the spectral composition of light given by many mantles, as they age, is often very marked.

The flame of burning magnesium is a well-marked instance of selective radiation. In Fig. 9 is to be seen a very steep rise in the curve due to luminescence in the violet, while yet higher regions in the ultra-violet occur.

In Class III. we number those sources of light which do not develope continuous

TABLE I.

Values for the ratio daylight/C_2H_2 averaged by groups and reduced to the basis of equal brightness of both spectra at wave-length of ·59 x 10^{-4} cm.

Stations	WAVE-LENGTHS IN 10^{-4} cm.						
	·725	·620	·590	·530	·460	·420	·390
At Sea	·367	·739	1·00	1·78	2·87	3·75	5·12
Algiers	·466	·764	1·00	1·47	2·37	2·97	2·96
Biskra	·538	·835	1·00	1·38	1·93	2·56	2·95
Naples	·444	·962	1·00	2·01	3·09	4·08	4·65
Palermo.....	·566	·873	1·00	1·24	1·85	2·52	2·81
Taormina	·423	·844	1·00	1·49	1·80	2·26	2·92
Bebek	·640	·928	1·00	1·17	1·52	1·84	2·03
Vienna	·562	·742	1·00	1·46	2·05	2·36	2·62
Zell	·528	·922	1·00	1·18	1·58	1·93	1·89
Sterzing	·468	·852	1·00	1·28	1·99	2·52	2·54
Trafoi	·358	·804	1·00	1·35	2·17	2·74	2·62
Brienz	·388	·848	1·00	1·33	2·96	3·43	3·23
Rothhorn	·334	·824	1·00	1·39	2·73	3·28	3·22
Misc. (Swiss) ...	·347	·850	1·00	1·42	2·17	2·70	2·57
Misc. (other) ...	·460	·900	1·00	1·33	2·39	2·77	2·83
Averages—							
Swiss, &c.	·420	·859	1·00	1·35	2·19	2·73	2·58
Averages—							
Lower Stations...	·490	·866	1·00	1·31	1·87	2·34	2·67
Averages—							
All Stations	·450	·865	1·00	1·34	2·07	2·59	2·63

spectra, such as the mercury arc, the flame arcs, &c. It is extremely difficult to compare such sources with daylight, except when the lines in the spectrum are crowded close together and very

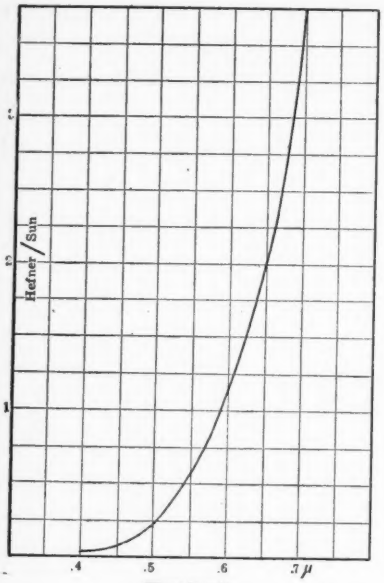


FIG. 7.

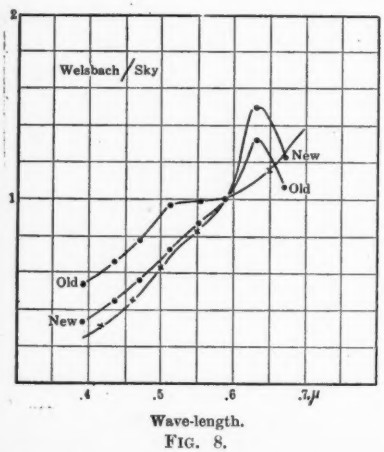


FIG. 8.

uniformly distributed. But in such cases as that of the mercury arc, in which the light is practically concentrated in three bright groups of lines in the yellow, green, and violet respectively, exact comparison becomes impossible.

In the DISCUSSION PROF. HALLOCK remarked that the results shown in Fig. 4 illustrated our ultimate goal in illuminants. We could not easily hope to attain the enormous temperature of the sun, but might reach an even better result by some means analogous to those utilized by the firefly, the light from which yielded an energy-curve with its maximum within the visible spectrum.

MR. J. W. HOWELL said that the reason for the spectra of the various glow-lamps

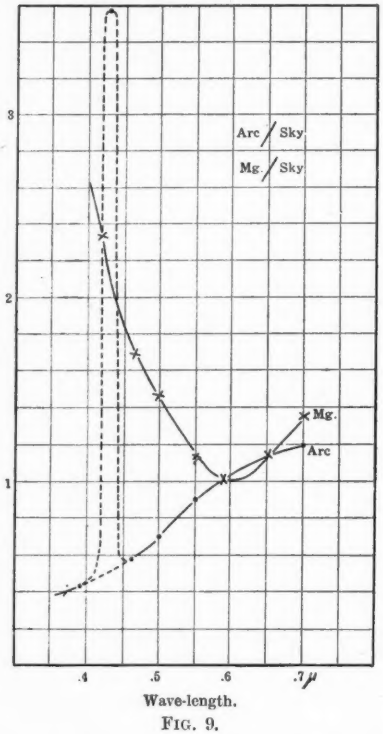


FIG. 9.

resembling each other so closely seemed to lie in the fact that, though their temperatures differed somewhat among themselves, they lay relatively near together, compared with the temperature of the sun.

MR. A. H. KELLOG drew attention to the claims made for some illuminants—for the tungsten lamps for instance—that the whiteness of their light enables the colours of illuminated objects to be more easily discriminated than in the case of other sources. In view of Dr.

Nichols's conclusions as to the similarity of the spectra of such illuminants, were we to regard these claims as unjustifiable ?

Mr. P. S. Millar remarked on the fact that in the case of artificial light the eye appeared to be satisfied with an illumination of about 3 foot-candles, in spite of the fact that daylight-illumination was usually so much higher. Was this in any way connected with the difference in colour of daylight and artificial illuminants ?

In reply Dr. Nichols said that the general character of the spectra of two illuminants might appear very similar, and yet colours, illuminated by the two sources, might present very different appearances. He thought that the difference in the intensities of the illumination desired in the case of daylight and artificial illumination might be partially attributed to the greater diffuseness of the former. He understood that it was an established fact that people expected a higher order of illumination to read by in rooms lighted by concealed sources.

It was improbable that temperatures very much higher than that of the carbon arc would ever be used for the production of light. There was still an almost untouched field for research in luminescence and phosphorescence effects. The difficulty, of course, was that in such cases a narrow band of light was almost invariably produced, instead of a continuous spectrum. Conceivably, by securing overlapping bands it might be possible to imitate natural daylight fairly well.

Bees and Ultra-Violet Light.

Lord Avebury, in the course of a lecture recently delivered at the Franco-British Exhibition, referred to the range of frequency of light-vibrations visible to bees. These insects, he thought, could certainly distinguish colour, though the range of colour that appealed to them might be different from that recognized by us. There was reason to believe, for instance, that ultra-violet light, which could not be detected in the form of light by our eyes, was visible to theirs.

A Novel Use for Incandescent Gas-lights.

A novel method of dealing with sewage gases has recently been proposed by the city engineer and bacteriologist of Winnipeg. The gases are led up the lamp-post to an incandescent gas-burner, where the bad air feeds the flame, and so becomes automatically sterilized.

It is stated that one lamp per 500 feet of sewer would be required, and that the expense would be at least no higher than that of existing systems of ventilation. The effectiveness of the method was tested by allowing the air to impinge upon glass plates containing suitable culture-media, both before and after passage through the burner. As a result it was found that a plate which was exposed to the gas *before* entry developed several hundred micro-organisms. In the case of the gas which had passed through the burner, however, not a single germ could be detected.—*The Acetylene Journal*, Chicago.

Light and Colour in Decoration.

By G. Leland Hunter.

(Abstracted from the *Transactions* of the Illuminating Engineering Society, March, 1908.)

Mr. Hunter dealt mainly with the value of lighting effects from the decorative standpoint. He commented upon the marvellous development in our methods of producing light, but remarked that we had yet to learn to employ our tools skilfully.

The author especially emphasized the necessity of avoiding violent contrasts either of light or colour, and drew attention to a common misconception that, in order to balance the effect of, say, a pronounced red-coloured wall-paper, a room ought to be illuminated by sources of light screened by means of green shades. The effect of this was that where the green light, coming through the semi-transparent shade, struck the wall, the latter appeared "muddy" and dark, while its red appearance was intensified by the bright patches of light from unshaded portions of the illuminant. The author contended that the correct course in such a case is to use a *red* shade, for naturally only red light is of any real service in illuminating such a background. In the same way the colour of a mercury lamp is less marked when used to illuminate green foliage, &c.

Mr. Hunter also put in a plea for the use of light in order to illuminate walls and ceilings. Many illuminating engineers were only content when they had arranged that the light was almost entirely cast in a downward direction upon the table, &c., that it was mainly intended to illuminate. This idea was incorrect, however, because the violent contrast of light and shade so caused was in itself distracting to the worker. Apart from this the walls and ceilings of a tastefully decorated room were in themselves deserving of illumination. Dark walls and ceilings should be avoided as far as possible from the point of view of successful illumination. When this was impossible the sources of light should be distributed, and, above all, should be enclosed in suitable globes so as to break the light up without the assistance of the reflecting power of surroundings.

The author also remarked upon the effect of different colours in causing the background to recede or advance; this, he seems to suggest, depends more upon difference in shade than difference in colour. The nature of the illumination adopted, and the amount of light that is to be allowed to fall upon the surroundings, also depends upon the dimensions of a room—on the height of a ceiling for instance. A light which would be dazzling to the eye three feet away is less so at nine. The decorator is often in a position to modify or accentuate the effects originally produced by the architect. For instance, if the ceiling of a small room gives the impression of being too high, this impression may be corrected by keeping the ceiling and floor dark and the walls bright. In general, however, floors should be dark in pattern, so as to give the impression of security. People frequently slip on parquet floors, not so much because the surface is slippery, as because it appears insecure.

In the discussion that followed the paper, Mr. H. F. Huber pointed out how the decorator could assist the scheme intended by the architect, and the illuminating engineer could assist the decorator. In order to secure a harmonious result all the trades interested must co-operate and learn to appreciate each other's point of view.

Mr. E. Y. Porter questioned the suggestion of Mr. Hunter that a glaring source became less troublesome to the eye as the distance of the eye was increased. Roughly speaking, the brightness per unit area of the image formed upon the retina is independent of the distance. Dr. Louis Bell pointed out that the colours of ordinary decorative papers were rarely pure. Mr. A. J. Marshall said that for all ordinary purposes it was really most essential to throw the majority of the light downwards. If one relied upon the reflected light from walls and ceilings for this purpose it certainly became very expensive. On the other hand, he agreed that the upper part of the room ought not to be in actual darkness.

In replying, Mr. Hunter said that, with reference to the point raised by Mr. Porter, one undoubtedly did find in practice that the nearer the eye to a bright source the more trying the effect. This became very evident if one placed a naked filament lamp a few inches from the eye.

REVIEWS OF BOOKS.

Les Nouveaux Modes d'Eclairage Electrique.

By A. Berthier.

(*H. Dunod et E. Pinat, Paris.*)

The main object of this book is to furnish an up-to-date description of the most modern methods of electric lighting. The chapters devoted to definitions of terms used in illumination and photometry, while mentioning instances of the most recent progress in photometers, &c., hardly serve to do more than afford an indication of the scope of this subject.

Chapter iii., however, contains an interesting and readable discussion of the scientific basis underlying the production of light, including a résumé of the recent developments in the theory of radiation.

The main portion of the book, occupying rather over 200 pages, is devoted to a résumé of the three methods of electric lighting by arc-lamps, glow-lamps; and vapour-lamps respectively. The description of the various lamps and the scientific principles involved is readable and up to date. We find, for instance, reference to such sources of light as the magnetite arc, the Küch mercury vapour lamp, and the Moore tube, and the section dealing with glow-lamps contains a brief summary of the recent work in attempting the manufacture of filaments of zirconium, niobium, silicon, &c. We notice a few misprints, of which "Hollfreund" for *Hollefreund*, "Zernig" for *Zerning*, and "Wittmann" for *Whitman* are examples.

The contents of the book are presented in an attractive and readable form, and it should be of service to those anxious to form some conception of the recent developments in electric lighting. Without detracting from the value of the book, we might suggest that fuller details of the exact references from which the author is quoting would sometimes be desirable. In some instances the references are given in full; in others, however, the journal quoted from is mentioned without date, and in others again only the authority is cited. This is the more to be regretted because the author seems to be in touch with international literature dealing with his subject, and makes many references which the casual reader would probably wish to follow up in detail.

Traité Théorique et Pratique de la Fabrication du Gaz.

By E. Borias.

Second Edition, revised by E. Borias and M. Fréchou.

(*Librairie Polytechnique ch. Béranger, Paris.*)

Some idea of the extent of the ground covered in this book will be gathered from the fact that it consists of exactly 600 pages. As its title suggests, the book deals mainly with problems of generation and distribution of gas, although there are also chapters included on its application to heating and lighting purposes in practice.

The first two chapters are given up to a review of combustible minerals and apparatus for distillation, the process of distillation, refinement, and storage being considered more completely in chapters vii. to xii.

Chapters iii., iv., and xviii. deal with the application of gas for heating purposes, chapter iv. containing a scientific discussion of flame temperature and calorific values and their measurement. Other portions of the book deal with the design and management of retorts,

chimneys, and the production and analysis of ammoniacal liquors. Of chief interest from our point of view are chapters xvi. and xvii., which deal with the use of gas for lighting and photometry respectively. We feel, however, that, though the avowed object of this book is to deal with problems of generation rather than with illumination, it would be well if, in future editions, a little more attention were bestowed on this subject in a chapter specifically devoted to gas lighting. Actually the chapter deals with theories of combustion, illuminating power, burners, and ventilation, but hardly touches on the subject of illumination proper. The chapter on photometry also hardly seems to contain as full treatment as we should expect to find in a book of the size and scientific scope of that undertaken by M. Borias. The single page devoted to standards of light (p. 456) seems to convey the impression that England and Germany still rely upon candles as photometric standards, and that the Vernon Harcourt and Hefner standards have merely been suggested and never came into actual use, and the only standard described is the Carcel lamp.

However, bearing in mind the main objects of the book and the extent of the ground to be covered, we do not doubt that this will be found a very useful book of reference to the gas engineer interested mainly in this aspect of the subject. Matters more closely connected with problems of generation are referred to from a scientific standpoint, and with greater detail. One feature of the book which should be found of special value is the exceptionally generous use of tables giving data of analyses, &c., often of a nature not easily found when wanted.

The contents of the 88 pages devoted to the initial tables constitute an interesting illustration of the amount of scientific information with which the expert gas engineer of the present day is expected to be acquainted.

Publications Received.

[We mention below a few of the books and pamphlets which have reached us during the present month, to some of which we mean to refer in greater detail in a subsequent number.]

Le Nuove Lampade Ellettriche ad Incandescenza. By G. Mantica. (Milan, Biblioteca dell' Associazone Utenti Energia Ellettrica d'Italia.)
A text-book devoted to the incandescent lamp, and including a review of the most recent developments in graphitized and metallic filaments.

Lichtstrahlung und Beleuchtung. By Paul Högner. (Brunswick, Friedr. Vieweg & Sohn.)
A treatise on illumination and the distribution of light, including particulars of the polar-curves of various illuminants and their application to the calculation of ground illumination, &c., under practical conditions.

Indirekte Beleuchtung von Schul- und Zeichen Sälen mit Gas und elektrischem Bogenlicht. (Berlin and Münich, R. Oldenbourg.)
A very complete account of the researches carried out by the commission appointed by the Deutscher Verein von Gas- und Wasserfachmännern, on the lighting of various schools in Münich.

Vorschriften für die Lichtmessung an Glühlampen nebst Photometrischen Einheiten. (Berlin, Julius Springer.)
A copy of the regulations relating to the photometry of glow-lamps, and the photometric units as prescribed by the Verband deutscher Elektrotechniker.

Über Schaufensterbeleuchtung mit Pharos-Licht.
A reprint from the *Journal für Gasbeleuchtung* containing particulars of some examples of shop lighting by gas at the recent Augur exhibition in Berlin.

We have also to acknowledge the receipt of an excellently got-up series of bulletins and papers on various matters connected with gas-lighting published by the Welsbach Co., Gloucester, New Jersey, U.S.A.

CORRESPONDENCE.

The City Lighting.

To the Editor of 'The Illuminating Engineer.'

SIR,—from the Report of Mr. Voysey on the Public Lighting of the City of London, which you printed in full in your last number, I am glad to see that he has "formed the opinion from observation and testing that the minimum illumination is the most important factor in good lighting." As you are aware, I have advocated for several years that comparisons of street illumination should be based on the minimum illumination obtained in any part of the road or pavement; but as there are still those who believe that such comparisons should be based on the average illumination, it is gratifying to note that Mr. Voysey, with his wide experience, both of testing and adjudicating on various methods of street illumination, has come to the same conclusion.

I sincerely trust Mr. Voysey will be permitted to carry out the whole of the scheme he proposes, namely, to erect large units of light in the main streets in such positions as to also illuminate the smaller branch streets for a certain distance, combined with smaller units of lights for the remainder of the side streets, which could be lighted and extinguished automatically at the same time as the large units, as such a scheme would result in the City being probably the best and most economically illuminated capital in the world. Yours, &c.,

HADYN T. HARRISON, M.I.E.E.

To the Editor of 'The Illuminating Engineer.'

July 17th, 1908.

DEAR SIR,—I have followed Mr. Voysey's remarks on street lighting with great interest.

Though the report deals mainly with matters of fact and observation, rather than of opinion, there is one point, it seems to me, which Mr. Voysey might have insisted on more rigidly, namely, the importance of uniformity of illumination. A dull, uniform illumination is much better than a bright, patchy one, at any rate from the physiological standpoint; and from this point of view flame arcs with inclined carbons are unsatisfactory.

The lighting of Holborn Circus appeared to me, during my visit last winter, to be a case in point. The illumination, on the whole, seemed to be brighter than in the adjacent streets, but the irregularity of the ground illumination rendered the result less effective than it should have been.

I hope that in street illumination projects of the future some form of vertical carbon flame lamp will be used, so that the illumination of the surface may be as complete as possible.

I am, yours very truly,

E. W. MARCHANT.

DEAR SIR,—Referring to the Editorial in your last issue, I think the establishment of an independent authority for photometric measurements would have much to recommend it. Such an arrangement would probably be most satisfactory to those electrical engineers who, like myself, believe that modern arc-lamps have nothing to fear from any system of gas-lighting.

The street-lighting in Manchester is already under observation by a department independent of both the gas and electric lighting concerns, and photometric tests are constantly made on the various lamps installed in the streets. Unfortunately it is, at present, extremely difficult to obtain a basis

of comparison that would be mutually satisfactory to everybody concerned.

I think most authorities are agreed that for the best results the following conditions would have to be fulfilled :

1. High average illumination.
2. The smallest possible difference between the highest and lowest illumination.
3. A few powerful lights placed high up, as far as possible above the line of sight, giving illumination curves with long gentle gradients.

I believe that the ratio between the highest illumination and the lowest illumination is as important as the minimum illumination. Patchiness of illumination, particularly where a large number of small points of light are distributed over the surface, is most confusing to the traffic and trying to the eyes.

Few realize the sensitiveness of the eye undisturbed by patches of brilliant light. An interesting experiment of Sir William Huggins was to place an observer in a room from which all light was as far as possible excluded, and the window blocked by one inch boards covered by several thicknesses of dark brown paper. Bright summer sunlight was shining upon the exterior brick wall of the room, and although absolute darkness was the impression given when first entering the room, it was found that after the stay of half-an-hour or so, the observer could distinguish objects, and see his way dimly about the room.

The colour of the light is also an important factor in giving good visual illumination apart from what I may term photometric illumination.

The interesting article by Dr. Louis Bell in your June issue deals with this very clearly, and I believe it is now generally admitted that a slightly yellowish light is more comfortable to work by than a white, greenish, or bluish light. This, at any rate, holds good after sunset hours.

There is no doubt that for any comparisons of two systems of lighting, each system should be installed in the manner deemed best by its advocates, with due regard to traffic obstruction, &c., but I fear that even then the best photometric experts might not come to conclusions satisfactory to everybody.

It is possible that a 'bus driver, for instance, would have different views on the matter. I have frequently listened to their criticisms of lighting with great interest.

After all, rivalry is very essential for progress, and gas probably owes as much to electric lighting as electric lighting owes to the incandescent gas-mantle.

I remain, Sir,
Yours faithfully,
A. DENMAN JONES.

Acetylene v. Petrol-Air Gas.

To the Editor of 'The Illuminating Engineer.'

DEAR SIR,—I beg to enclose herewith a reply to Mr. Bingham's paper on 'Acetylene *versus* Petrol-Gas' as follows.

ECONOMY.

1. *Cost of Apparatus.*—With regard to the first cost of the plant for the rival systems, the advantage in the smaller sizes is with the "acetylene," but for larger sizes such as 150 up to 1,000 lights this advantage entirely disappears, and is rather on the other side. The comparisons given on p. 548 are, as far as the De Laitte plant is concerned, erroneous. For instance, this states that a 20-light De Laitte plant costs 48*l.* 10*s.*, whereas that is the price of a 30-light machine. 70*l.* is stated to be the cost of a 50-light plant, whereas that is the catalogue price of the 70-light plant, and 90*l.* the price for a 100.

Moreover, whereas the Acetylene Gas Plant Manufacturers rate their machines upon the 30 C.P. basis, we rate ours on a 50 C.P. basis, so that,

light for light, our 30-light machine is equal to an acetylene plant of 50-light capacity, and so on in proportion, so that on the 30 C.P. basis for the 90*l.* mentioned on p. 548 a "De Laitte" plant of 166-light capacity may be obtained.

2. *Cost of Piping.*—In this country very small piping is generally used for acetylene; this small piping is more economical than the ordinary size gas-piping such as is used with coal gas and the De Laitte gas also. It is more easily concealed in mouldings, &c., but experience has proved that the deposit from acetylene comparatively soon chokes these small-diameter pipes, with the result that considerable expense is incurred in cleaning them out, or they have to be renewed entirely.

In Australia, where acetylene is very largely used, this difficulty caused by the stoppage of pipes has long been recognized, with the result that large-size pipes are invariably used, the advantage claimed under this head in the first instance being thereby eliminated.

3. *Cost of Burners.*—It is true that the first cost of an acetylene burner is very considerably cheaper than that of a burner specially designed for use with petrol gas; but it must not be forgotten that whilst the life of a petrol gas burner is anything from 4 to 8 years, owing to the deposit caused by the gas, the former becomes choked in a few months.

4. *Fittings* —The cost of these would be the same for either gas, but the choice of upright or inverted burners gives to petrol gas a distinct advantage as far as design is concerned.

5. *Cost of Running.*—Careful tests have shown that the costs for maintaining a 40 to 60 candle-power burner with petrol at 1*s.* 4*d.* per gallon to be one-fourteenth of a penny. These figures can be proved at any time with comparatively little trouble by any one sufficiently interested.

SAFETY.

Safety in the Dwelling.—It is well known and admitted by Mr. Bingham in his paper that there is no record of any explosion having taken place through the escape of petrol-gas in the building, but a glance through the files of our newspapers reveals many such explosions caused by acetylene.

Safety of Plant.—As regards the gas-generating plant, many of the leading fire insurance companies now recognize the absolute safety of the De Laitte plant, and have removed all restrictions.

Safety of Raw Material.—With regard to the raw material itself, this in the case of the De Laitte system is stored in patent storage tanks of such absolute safety that whether they are full, half full, or nearly empty, a lighted match even can be dropped into the tank and the resultant flame extinguished by means of a piece of paper, such a thing as an explosion being absolutely impossible.

From the extract of the *Revue des Éclairages* of January 15th last an erroneous conclusion is drawn, the thirty-seven accidents reported as having been caused by petrol refer to the motor industry and not petrol-lighting, whilst it is admitted that two at least were caused by acetylene.

HEALTH.

(*a*) *Effect on the Eyesight.*—As it is an indisputable fact that the petrol gas light is practically the only lighting in which the ultra-violet rays are absent, further comment on this subject is unnecessary.

(*b*) *Effect on the Atmosphere of the Room.*—With the properly regulated petrol gas burner no additional oxygen is taken from the air of the room.

Many unbiassed users of acetylene light admit the feeling of lassitude which attacks them after remaining an hour in a room which is lighted by that means.

CONVENIENCE.

I am glad to see the admission made that it is easier to fill the petrol tank with liquid than to fill the trays of an acetylene generator with carbide and remove the "sludge," which is a particularly appropriate name for the offensive residue.

An additional advantage which has been lost sight of by Mr. Bingham is that with the petrol gas plant the

supply can be renewed whilst the machine is working.

My answers to the alleged disadvantages of petrol gas are as follows:

1. Petrol gas as manufactured by the De Laitte system cannot, at any rate in the inhabited parts of the world, revert to a liquid, since the vapour of any liquid will only revert to its former liquid form when the same temperature or a lower is attained as that at which it is given off, a temperature which in the case of De Laitte gas is minus 14 Fahrenheit, hence the imposibiity of condensation of the petrol, and as the air with which the petrol vapours are (in the case of the De Laitte machines) intimately mixed, is anhydrous, there is no possibility of condensation of the natural moisture, which would otherwise be present in the air.

2. With the De Laitte plant no hot air motor is used, no more attention or need of a "fairly clever mechanic to look after it," is necessary than is the case with an ordinary grandfather's clock, and where water pressure is available even this winding-up is done away with, and the plant will require attention only once in eight or ten weeks for the purpose of renewing the petrol supply. So much cannot, I think, be said for acetylene.

The Objection to the Blackening and Bursting of Mantles, when the gas is first turned on, is entirely removed in the De Laitte plant owing to the intimate mixture of the gas when first made. There being no natural moisture in the air the vapour of the petrol is held in suspense.

GENERAL APPEARANCE.

It is admitted on all hands that, owing to the entire absence of ultra-violet rays, petrol light is the only light which shows persons and objects in their true colours, and a prettily and artistically decorated room is never seen to better advantage than when illuminated by petrol light in conjunction with inverted fittings and tastily designed shades.

CONCLUSION.

Throughout the whole of Mr. Bingham's paper I fail to find any reference made to the obnoxious smell inseparable from the charging of the acetylene retorts, the disposal of the "sludge," or, above all, from an escape owing to a leak in the pipe or the accidental turning on of a burner. Neither has Mr. Bingham called attention to the very great difference between the space required for a plant capable of supplying 100 lights, and this becomes more pronounced as the size of the plant increases.

I remain, yours faithfully,

J. WILLIAMS

(The De Laitte Gas Machine Syndicate, Ltd.)

The Temperature of the Sun.

SIR,—I notice in your abstract of Herr K. Sartori's recent paper on the temperature of incandescence of glow lamps, what seems to be an erroneous method of estimating the temperature of the sun.

The author applies Wien's law $\lambda_{max}.T = \text{constant}$, to the energy curve of the spectrum of sunlight *as it reaches us*. Probably, however, the maximum of the energy curve of solar radiation, in the condition in which it starts from the sun, would be very much displaced into the ultra-violet. We know from S. P. Langley's researches how influential is the effect of the earth's atmosphere in absorbing these rays, and how the energy maximum of solar radiation moves towards the blue end of the spectrum as we ascend a mountain.

Whether we are justified in applying Wien's law to solar radiation on general grounds or no, it seems highly probable that any result deduced from the energy curve, as obtained on this earth, must be too low.

I am yours truly,

I. WANTERNO.

The Second Annual Convention of the Illuminating Engineering Society.

We have received a notice of the above Convention, which is to be held in Philadelphia, U.S.A., on Monday and Tuesday, Oct. 5th and 6th of this year. We wish to draw special attention to the extremely wide range of attractive subjects covered by the papers to be presented at the Convention. In order to facilitate discussion, it is proposed to circulate advance copies of these papers among the members of the Society attending the Convention, and then to read the various contributions in abstract or by title only.

Programme of Papers.

President's Address. By Dr. Louis Bell.

Architecture and Illumination. By Mr. Emil G. Perrot, Philadelphia.

Modern Gas Lighting Conveniences. By Mr. T. J. Litle, Jun., Philadelphia.

Railway Car Lighting. By Mr. H. M. Davies, Philadelphia.

Relation between Candle Power, Voltage and Watts of Different Types of Incandescent Lamps. By Dr. F. E. Cady, Washington, D. C.

Illuminating Value of Petroleum Oil. By Dr. A. H. Elliot, New York.

Structural Difficulties in Installation Work. By Mr. J. R. Strong, New York.

Street Lighting Fixtures, Gas and Electric. By Mr. H. Thurston Owens, New York.

Oil Burners. By Mr. W. T. Sterling, New York.

Design of the Illumination of the New York City Carnegie Libraries. By Mr. L. B. Marks, New York.

Intensity of Natural Illumination throughout the Day. By Mr. L. J. Lewinson, New York.

Calculation of Illumination by Flux of Light Method. By Messrs. J. R. Cravath, Chicago, and V. R. Lansingh, New York.

Specific Intensity of Lighting Sources. By Mr. J. E. Woodwell, Washington.

Design of Reflectors for Uniform Illumination. By Mr. A. A. Wohlauer, New York.

The Ives Colormeter in Illuminating Engineering. By Dr. H. E. Ives, Washington, D.C.

International Unit of Light. By. Dr. E. P. Hyde, Washington, D.C.

Some Experiments on Reflections from Walls, Ceiling, and Floors. By Messrs. V. R. Lansingh and T. W. Rolph, New York.

The International Electrotechnical Commission.

The first meeting of the International Electrotechnical Commission is to be held in London on Oct. 19th, and probably at the new home of the Institution of Electrical Engineers. It is expected that delegates from all the chief countries concerned will be present.

Review of the Technical Press.

Illumination.

Among the most important papers that have recently appeared bearing on this subject mention must be made of that of A. Broca and F. Laporte on the hygienic aspects of the principal illuminants from the point of view of eyesight (*Bull. Soc. Int. des Electriciens*, June). The authors have carried out an extensive series of tests on the effect of the mercury-vapour lamp and the carbon filament lamp on the eye, including experiments on the effect on visual acuity, speed of reading, and the contraction of the pupil orifice. On the whole, their results appear to suggest that no marked difference due to the colour of these two sources of light could be detected.

The authors also study the effect of varying the illumination on acuity, and come to the conclusion that a value of 20 to 40 lux suffices. They also condemn the placing of bright sources of light in such a way as to be visible to the eye, if only obliquely, as a prevalent cause of eye fatigue. Curiously enough they appear to have found that a bright source of light that was visible out of the tail of the eye increased acuity in some cases —possibly by causing the pupil orifice to contract—but the effect was also very fatiguing.

Schanz and Stockhausen have recently delivered a paper before the Verband Deutscher Elektrotechniker on the injury that may be caused to the eyes by ultra-violet light. They allude to the effect of these illustrated by cataract, inflammation of the eyelids, and snow-blindness. It is pointed out that ordinary glass does not provide a complete screen against these rays, letting through those between 0·4 and 0·3 μ, which the authors consider to be amongst the most injurious. They then proceed to describe a type of glass termed "Euphos," which, they claim, has the property of absorbing the most obnoxious rays completely.

Cravath and Lansingh (*Elec. World*, July 11) contribute an article giving some approximate data for the predetermination of illumination. A table is also provided specifying the approximate number of watts per square foot of floor area that must be allowed in order to secure an illumination of one foot-candle in the case of a series of different illuminants and different arrangements of them. The results refer to a plane 30 inches from the floor. Two values are quoted in each case, corresponding to a room with light and dark wall-papers and decoration respectively.

The Electrical Review of New York (June 11th) contains an article by Lansingh on illumination from the contractor's point of view. Here the necessity for attention on the part of the modern contractor to illumination problems, as distinct from the study of matters of wiring only, is insisted upon.

Wohlauer (*Elec. World*, July 4th) again discusses the problem of securing a perfectly uniform horizontal ground illumination. He deduces the form of polar curve necessary in order to obtain a given intensity of uniform illumination, and works out some formulæ connecting the distance between the lamps, the height of suspension, and the degree of illumination required. Assuming certain premises, he shows how to calculate the number of lamps required by means of a simple formula.

A recent number of *The Electrical World* also contains an account of the illumination of the Singer tower by a somewhat novel method, involving the lighting up of the exterior by means of shielded glow-lamps and search lights; the article is accompanied by several interesting photographs and diagrams showing the general effect and the number of lamps required throughout the building.

Photometry.

The report of the Committee on Photometry of the Verein von Gas- und Wasserfachmännern has now been published.

The Committee have been considering the possibility of adopting the regulations of the Verband Deutscher Elektrotechniker, designed for the photometry of electric lights, in the case of gas-lamps. They adopt the mean lower hemispherical candle-power of the source of light as the best basis of comparison, though they insert a caution against the application of this factor too rigidly, without due regard to the special circumstances of the case under consideration. They also discuss the applicability of the Ulbricht globe to the photometry of gas-lights. The main consideration in this case is the possibility that the confined space in which the source is enclosed might cause the air-supply to differ from that occurring when the lamp is in actual use. It is known that a very small difference in this respect may very seriously affect the performances of inverted burners. The Committee, however, decide to make further researches on this point. Other matters dealt with in the report include details of gas-testing and the effect of transmission for long distances under pressure, on the calorific and illuminating power of the gas ultimately delivered. Both these quantities appear to be but slightly affected.

Krüss (*J.f.G.*, July 4th) describes a new form of integrating photometer of the mirror type. He points out that in photometers of this class it is necessary to introduce the factor "cos α" referring to the angle α at which the ray strikes the mirrors, and explains how this was attained by Blondel, Matthews, &c. He himself utilizes a series of lenses to concentrate the individual beams and introduces the required correction for "cos α" by placing suitably graded stops in front of them.

Paulus completes his article on different methods of measuring the mean horizontal candle-power of glow-lamps (*Z. f. B.*, June 30th). He comes to the conclusion that neither measurement in a single direction nor measurement with a mirror can yield correct results in the case of metallic filament lamps, because both these methods demand an approximately uniform distribution of light.

The rotation method, which is not open to this objection, was found to yield much better results, the author recommending a frequency of rotation of from 40 to 80 per minute. Under these circumstances the centrifrugal force does not suffice to produce any marked deformation, and it is stated that no lamps were broken in the rotating holder, notwithstanding the fact that many were smashed in transport. The author also quotes figures to show that the "flicker" at this speed did not seriously interfere with the accuracy of observation. The portable photometer of Siemens and Halske is described in the *Zeitschrift für Beleuchtungswesen* (June 30th); it will be remembered that this was dealt with in the review for June (*Illuminating Engineer*, June, p. 523).

Electric Lighting.

Several interesting papers were read at the annual meeting of the Verband Deutscher Elektrotechniker last month, but they have only been shortly referred to as yet, and we still await complete publication. Special interest attaches to that by Wedding on recent progress in electric illuminants, and Remané on the effect of overrunning metallic filament lamps, and a comparison between the upkeep of small arc-lamps and high candle-power osram lamps. Remané has also contributed an article on the subject of the 1 watt per H.K. glow-lamp to a recent number of the *E.T.Z.* He quotes a number of data on the relative costs of lighting by metallic filament lamps and gas, and seeks to show that the 1 watt per H.K., 16 candle-power, 220 volt lamp will not really be desired either by supply companies or the consumer, because electricity can now compete with gas even when lamps of 25 or even 35 H.K. are available. Moreover, he points out that the gas companies have habitually used units of 50 to 60 H.K., and would ridicule the use of 16 H.K. units. In reality, therefore, the coming of the 1 watt per H.K. glow-lamp only enables the consumer to secure an amount of light he ought by rights to demand, but could not hitherto obtain cheap enough.

In opposition to this view it is interesting to note that Wedding, in the article above referred to, speaks of the 220 volt 16 H.K. lamp as the ultimate goal of the lighting industry.

Remané, however, also expresses the hope that the lamp-makers will not be forced to supply high voltage and low candle-power lamps, because he feels that there is no prospect of producing such lamps to give as good results as those obtainable for low voltage ones. This has already been their experience in the case of the carbon lamps, and is yet more true of the metallic filament ones.

Another interesting comment on this question is furnished by some tests, published in the *Elektrotechnische Zeitschrit* for June 4th, on the 220 volt Just-Wolf

ram lamps, according to which the lamps gave excellent results both on direct and alternating current running, however, at an efficiency of about 1·25 watts per H.K.

The prospects of the tungsten lamp also form the subject of a recent paper by Tweedy (*Elec. World* and *Elec. Review* of New York, July 4th).

A reference has also appeared in several of the American papers of a somewhat remarkable development of the Helion lamps; it is now claimed that these lamps can be run in the open-air instead of in an exhausted globe, as was formerly found to be necessary.

Mention may be made of a contribution by Duschnitz (*Elek. Anz.*, July 5 and 16), and the serial contribution in the *Zeitschrift für Beleuchtungwesen*, which have just been brought to a conclusion. Both these articles deal with recent developments in the manufacture of glow-lamp filaments, and contain references to the patent literature on the subject.

Schmidt (*Elek. Anz.*, July 23rd and 26th) contributes an interesting discussion of street-lighting by electrical methods. The article is especially interesting, in that it brings out the number of factors on which the relative economy of different systems depends. For instance, in addition to the cost of energy and maintenance of a given light we must bear in mind the number of lights that can be run in series off the supply and the system of supply adopted. A wide field for economy is also afforded by the choice of the method of grouping lamps, the number that are allowed to burn all night or half-nightly, &c. In this connexion the author gives a table showing the time that such lamps may be expected to have to burn in the different months in the year.

Finally, we may refer to a device that has been described in several of the German technical papers, its object being to draw attention to the behaviour of any distant arc-lamp, out of the observer's sight, that is not burning satisfactorily. This is accomplished by placing a number of glow-lamps on a central board visible to the observer, each of these being on a parallel with the particular lamp it is desired to study. Any abnormality in the behaviour of an arc-lamp and resulting fluctuations in the P.D. across it, is immediately indicated by the glow-lamp in parallel.

Gas, Oil, and Acetylene Lighting.

At the annual meeting of the Société Technique de l'Industrie du Gaz a number of short papers dealing with subjects of more or less interest to the illuminating engineer were read; these have been briefly reported in recent numbers of the leading English gas journals. One of the most interesting subjects brought up was the use of hydrocarbons derived from coal-tar for incandescent lighting. Portable lamps using derivatives of this nature have already been used in France and elsewhere with very satisfactory results, and it is stated that it is now possible to get half as much light from the coal-tar remaining after distillation as could formerly be obtained from the entire bulk of gas generated.

At the recent annual meeting of the corresponding German society Drehschmidt described the public lighting in Berlin, his address being briefly reported in the *Journal für Gas*, &c. (June 27th).

In a recent number of the *Journal of Gaslighting* some interesting particulars are given of a simple method of increasing the lighting efficiency of a burner. This consists in merely slipping a solid refractory conical body over the crutch on which the mantle is supported. The effect of this heated body is beneficial in directing the flame on to the mantle, and also, possibly, in raising the temperature. At any rate, it is stated that an increase in efficiency of 20 per cent is gained.

It is also stated that the wear and tear of the mantles is reduced, partly because the flame is steadied and the mantle does not rattle to and fro through draughts, and partly because the rapid heating and cooling that is supposed to be injurious to the ordinary mantle is modified by the presence of the heated body.

Grey (*Amer. Gaslight Journal*, July 6th) contributes a discussion of the hygienic aspects of gas-lighting. He puts forward the plea that gas-lights in general improve the ventilation, by causing an ascent of heated air, and adds a number of useful references on the subject at the conclusion of the article.

Among other articles on the subject of gas-lighting mention may be made of those occurring in the *Zeitschrift für Beleuchtungswesen* bearing upon new processes of treating incandescent mantles. The article by Monasch on the photometry of portable oil-lamps, occurring in the *Journal für Gasbeleuchtung* some time ago, has now been translated in *The Progressive Age* (July 15th).

Finally, attention may be called to some tests by Wedding on the Keith high-pressure inverted lamp, published in *The Journal of Gaslighting* (July 14th).

List of References:—

ILLUMINATION.

Broca, A. and Laporte F. Etude des Principales Sources de Lumière au point de vue de l'Hygiene de l'Oeil (*Bull. Soc. Int. des Electriciens*, June, 1908, p. 277).

Cravath, T. R. and Lansingh, V. R. Helps in Rapid Preliminary Calculation of Illumination (*Elec. World*, July 11).

Dagget, H. M. High Efficiency Illuminants (paper read before the Illuminating Engineering Soc., June 19).

Lansingh, V. R. The Contractor and Illumination (*Elec. Rev.*, N.Y., June 11).

Marshall, A. J. and Rolph, T. W. Artificial Lighting of Schoolrooms (*Illum. Eng.*, N.Y., July).

Schanz and Stockhausen. Die Schädigung des Auges durch die Einwirkung des ultravioletten Lichtes (paper read before the Verband Deutscher Elektrotechniker, abstr. *E. T. Z.*, June 25).

Wohlauer, A. A. The number of Lamps for uniform illumination (*Elec. World*, July 4).
The Boston Finance Committee and Street-lighting (*Elec. World*, June 27).
The Illumination of the Singer Building Tower (*Elec. World*, July 4).

PHOTOMETRY.

Krüss, H. Integrierendes Photometer (*J. f. G.*, July 4).

Morton, F. W. The History of Photometric Standards (*J. G. L.*, June 30 and July 7, abstr. from *T. I. E. S.*).

Paulus, C. Vergleich der verschiedenen technischen Methoden zur Bestimmung der mittleren Horizontallichtstärke von Metallfadenlampen (*Z. f. B.*, June 30).
Bericht der Lichtmesskommission (Report of Committee on Photometry appointed by the Deutscher Verein von Gas-, &c., abstr. *J. f. G.*, June 20).
Neues tragbares Photometer für elektrische Glühlampen (*Z. f. B.*, June 30, see also Schweiz., *E. T. Z.*, April 25, mentioned *Illum. Eng.*, June).

ELECTRIC LIGHTING.

Duschnitz, B. Metallische Leuchtfäden und Metallfadenlampen in der Fabrikation und in der Praxis (*Elek. Anz.*, July 5 and 16).

Remane, H. Beitrag zur Klärung der Frage betreffend die kunftige Entwickelung der einwattigen Lampe und der elektrischen Beleuchtung (*E. T. Z.*, June 11).
Der Einfluss von Überspannungen auf die Lebensdauer von Metallfadengluhlampen.
Vergleich von Betriebskosten kleiner Bogenlampen und hochkerziger Osramlampen (two papers read at meeting of the Verband Deutscher Elektrotechniker, abstr. *E. T. Z.*, June 25).

Schmidt, J. Ueber elektrische Strassenbeleuchtung, deren Systeme, und ihre Rationellität (*Elek. Anz.*, July 23).

Tweedy, E. F. The Tungsten Lamp (*Elec. Rev.*, N.Y., and *Elec. World*, N.Y., July 4).

Wedding, W. Uber neuere Errungenschaften der elektrischen Beleuchtung (paper read before the Verband Deutscher Elektrotechniker, abstr. *E. T. Z.*, June 25).
Die Just Wolfram Lampe für 220 volt (*E. T. Z.*, June 4, 1908).
Bogenlampen-Indikator (*E. T. Z.*, July 2, *Elek. Anz.*, July 9).
The Helion incandescent Lamp (*Elec. World*, N.Y., June 27).
Street-lighting in St. Louis (*Elec. World*, N.Y., July 4).
Fortschritte in der Glühlampen-Industrie (*Z. f. B.*, July 10).
Fortschritte in der Beleuchtungswesen des Bergwerksbetriebes (*Z. f. B.*, July 20).

GAS LIGHTING, OIL, AND ACETYLENE LIGHTING, &c.

Denayrouze. Use of Hydrocarbons derived from Coal-tar for incandescent lighting (*J. G. L.*, July 7).

Drehschmidt. Uber die öffentliche Beleuchtung in Berlin (paper read before the Deutscher Verein von Gas-, &c., reported *J. f. G.*, June 27).

Editorials. Electric Competition (*Progressive Age*, July 1).
Street lighting in the City of London (*G. W.*, July 11).

Grey, J. C. The Hygiene of Burning Gas (*Am. Gaslight Jour.*, July 6).

Monasch, B. The Photometry of Portable Oil Lamps (*Progressive Age*, July 15, trans. *J. f. G.*).

Wedding, W. Tests on the Keith High-Pressure inverted Lamp (*J. G. L.*, July 14).
The Annual Meeting of the Société Technique de l'Industrie du Gaz (*G. W.*, June 27).
A simple discovery increases lighting efficiency (*J. G. L.*, July 14).
Zur Frage des nächtlichen Schliessens einer Hausgasleitung (*J. f. G.*, June 27, July 11).
Verfahren zur Herstellung von Glühstrumpfen (*Z. f. B.*, July 10).
The International Congress on Acetylene, papers read before (*Acetylene*, July).
L'Eclairage des chemins de fer (*Rev. des Eclairages*, July 15).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
Elektrot. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society.*

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

12,736. Adjustably suspending incandescent lamps. June 13. C. E. Heldbek, 72, Cannon St., London.
12,968. Filaments for glow lamps (C.S.). June 17. H. Kuzel, 322, High Holborn, London. (Addition to 28,154/04.)
13,015. Incandescent lamps. June 18. J. Gray, 83, Cannon Street, London.
13,029. Metal filaments for incandescent lamps. June 18. T. W. Lowden and The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Building, Norfolk Street, Strand.
13,100. Arc lamps (C.S.). June 19. Miertschke, 65, Chancery Lane, London.
13,230. Lamp-holders. June 22. W. Fennell and W. P. Perry, 68, Dudley Road, Tipton, Staffs.
13,275. Arc lamps. June 22. The British Thomson-Houston Co., Ltd., and W. H. Dalton, 83, Cannon Street, London.
13,449. Incandescent lamps (C.S.). June 24. P. G. Triquet, 70, Chancery Lane, London.
13,580. Arc lamps (C.S.). June 27. Siemens Bros. Dynamo Works, Ltd., and C. R. Riber, York Mansion, York Street, Westminster.
13,661. Fittings for incandescence lamps (C.S.). June 27. A. G. Bloxam, Birkbeck Bank Chambers, London. (From Siemens Schuckertwerke G. m. b. H., Germany.)
13,733. High voltage adaptor for metallic filament lamps. June 29. F. Wisotzky, "Rose Lea," Station Road, Hendon, London.
14,183. Metallic filament lamps for high intensity of light (C.S.). July 3. (I.C., June 22, 1908, Germany.) W. Majert, 18, Southampton Buildings, London.
14,184. Metallic filaments for incandescent lamps. July 3. W. Majert, 18, Southampton Buildings, London.
14,237. Arc lamps. July 4. E. R. Grote, 40, Chancery Lane, London.
14,411. Electric lighting attachments (C.S.). July 7. A. J. Boult, 111, Hatton Garden, London. (From Benjamin Electric Manufacturing Co., U.S.A.)
14,436. Filament for incandescent lamps. July 7. The British Thomson-Houston Co., Ltd., I. W. Howell and H. H. Needham, 83, Cannon Street, London.
14,502. Metallic filament lamps (C.S.). July 8. (I.C., June 13, Germany.) W. Majert, 18, Southampton Buildings, London.

II.—GAS LIGHTING.

12,802. Turning lights on and off. June 15. G. Robson, 18, Southampton Buildings, London.
12,905. Globe-holders for inverted incandescent burners (C.S.). June 16. G. A. Akers, C. W. Akers, and A. E. Akers, 88, Chancery Lane, London.
13,204. Burning off gas mantles (C.S.). June 20. (I.C. Nov. 8, 1907, Germany.) H. Drehschmidt, 77, Chancery Lane, London.
13,324. Inverted gas arc lamp. June 23. F. G. Gumprecht, King's Oak Hotel, High Beech, Loughton, Essex.
13,439. Flash-light apparatus (C.S.). June 24. M. L. Krimer and G. A. Tee, 165, Queen Victoria Street, London.
13,621. Incandescent lighting apparatus. June 27. J. Webber, 18, Southampton Buildings, London.
13,693. Incandescent burners and anti-vibrating devices therefor (C.S.). June 29. T. Eaves, 4, St. Ann's Square, Manchester.
13,754. Incandescent lamps. June 29. E. C. P. Eddrup, H. F. Boughton, and W. H. Everson, 276, High Holborn, London.
13,828. Metallic incandescent mantle for lighting and heating (C.S.). June 30. H. Reeser and H. E. Bray, 20, Copthall Avenue, London.
13,912. Gas and air regulator for incandescent burners. July 1. C. J. Sutton and J. Rudd, Nelson Square, Bolton, Lancashire.
14,006. Incandescent mantles. July 1. L. St.-C. Fewings and Curtis's and Harvey, Ltd., 31, Basinghall Street, London.
14,061. Incandescent burners. July 2. A. C. Wigley and J. J. Rowe, 6, King Edward Parade, Ilford, London.
14,205. Means for carrying a shade or smoke consumer over an inverted incandescent burner. July 4. W. Beal, 128, Colmore Row, Birmingham.
14,253. Incandescent burners. July 4. C. Skaife and J. A. Gibson, 6, Lord Street, Liverpool.
14,470. Inverted incandescent lamp. July 8. W. Hotton, sen., 21, Charterhouse Buildings, Aldersgate, London.
14,631. Incandescent burners. July 10. W. Fitton, 4, St. Ann's Square, Manchester.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

12,991. Electric or gas pendants. June 18. E. C. Peck, 151, Victoria Road, Old Charlton, Kent.
12,995. Oil lamps. June 18. J. McNair, 154, St. Vincent Street, Glasgow.

13,321. Artificial light globe or chimney. June 23. J. Wale, 161, New Kent Road, London.
13,752. Incandescence vapour lamps. June 29. A. Kitson, Birkbeck Bank Chambers, London.
14,472. Lamps. July 8. J. T. Smith, 111, Hatton Garden, London.
14,497. Controlling from outside whether light is used in a room. July 8. W. Becker II., 345, St. John Street, London.
14,608. Incandescent lamps. July 9. W. Majert, 18, Southampton Buildings, London.
14,657. Search lights. July 10. Siemens Bros. Dynamo Works, Ltd., and G. S. Grimston, 139, Queen Victoria Street, London.
14,688. Acetylene lamps (C.S.). July 10. I. Fizel *née* Bona, 6, Lord Street, Liverpool.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

12,257. Arc lamps. May 25, 1906. Accepted June 24, 1908. W. J. Davy, 40, Chancery Lane, London.
8,947. Incandescent bodies for lighting and heating (C.S.). I.C., April 19, 1906, Germany. Accepted June 24, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
13,129. System for the electric lighting and heating of vehicles (C.S.). I.C. June 9, 1906, Germany. Accepted June 17, 1908. H. Grob, 37, Essex Street, Strand, London.
13,147. Enclosed arc lamps. June 6, 1907. Accepted June 17, 1908. J. Brockie, Birkbeck Bank Chambers, London.
13,190. Electrodes for arc lamps. June 6, 1907. Accepted June 17, 1908. H. T. Harrison and H. Hirst, 46, Lincoln's Inn Fields. London.
14,713. Arc lamp electrodes. June 26, 1907. Accepted July 8, 1908. H. S. Hatfield and F. M. Lewis, 18, Palmeira Square, Hove, Sussex.
15,367. Producing refractory conductors, particularly metal filaments. July 3, 1907. Accepted June 17, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
15,510. Illuminating bodies for incandescence lamps (C.S.). I.C. July 11, 1906, Germany. Accepted July 8, 1908. Deutsche Gasglühlicht Akt.-Ges. (Auerges), 55, Chancery Lane, London.
15,798. Incandescent lamp with metal filaments (C.S.). I.C. May 31, 1907, Germany. Accepted July 15, 1908. H. Kuzel, 322, High Holborn, London.
16,034. Pocket electric lamp. July 12, 1907. Accepted July 15, 1908. W. Thomson, Royal Institution Laboratory, Manchester.
16,053. Arc lamps. July 12, 1907. Accepted June 24, 1908. H. S. Hatfield and F. M. Lewis, 18, Palmeira Square, Hove, Sussex.
16,431. Incandescence lamps. July 17, 1907. Accepted July 15, 1908. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
17,817. Making joints in metal filament lamps. Aug. 6, 1907. Accepted July 15, 1908. A. C. Hyde, 7, Crown Office Row, Temple.
23,116. Metal-cored flame carbons for arc lamps. Oct. 19, 1907. Accepted July 15, 1908. M. Railing, M. Solomon, and H. E. Crocker, Witton, Birmingham.
24,138. Arc lamps. Nov. 1, 1907. Accepted July 8, 1908. A. D. Jones, Hartham Works, Hartham Road, Holloway.
24,299. Obtaining cold electric light by high tension electricity (C.S.). I.C. Nov. 3, 1906, Germany. Accepted July 1, 1908. D. Timar and K. von Dreger, 7, Southampton Buildings, London.
24,707. Refractory conductors (C.S.). Nov. 7, 1907. Accepted July 8, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
27,809. Incandescent lamps (C.S.). Dec. 17, 1907. Accepted July 8, 1908. E. C. R. Marks, 18, Southampton Buildings, London. (From Parker-Clark Electric Co., U.S.A.)
4,461. Filaments for illuminating and heating (C.S.). I.C. June 10, 1907, France. G. Michand and E. Delaseon, 7, Southampton Buildings, London.
5,783. Incandescent lamps (C.S.). I.C. March 16, 1907, U.S.A. Accepted June 17, 1908. J. W. Howell, 83, Cannon Street, London.
6,409. Incandescent filament lamps (C.S.). March 23, 1908. Accepted June 24, 1908. C. Pauli, 20, High Holborn, London. (Addition to 27,541/07).
9,636. Fittings for glow-lamps (C.S.). I.C. June 25, 1907, Germany. Siemens-Schuckertwerke G. m. b. H., Queen Anne's Chambers, Broadway, Westminster.
11,524. Metal incandescence filaments free from carbon (C.S.). I.C. June 8, 1907, Germany. Accepted July 15, 1908. Siemens and Halske Akt.-Ges., Birkbeck Bank Chambers, London.
11,603. Tungsten incandescence filaments (C.S.). I.C. June 8, 1907, Germany. Siemens and Halske Akt.-Ges., Birkbeck Bank Chambers, London. (Addition to 16,489/07).
12,656. Arc lamps (C.S.). I.C. July 8, 1907, Germany. D. Timar & C. von Dieger, 7, Southampton Buildings, London.
12,720. Incandescent lamp filaments (C.S.). I.C. July 13, 1907, France. Société Française d'Incandescence par le Gaz (Système Auer), 24, Southampton Buildings, London.
13,734. Electrodes for furnaces, radiators, lamps, &c. (C.S.). I.C. June 27, 1907, Italy. G. Cornaro, 72, Cannon Street, London.
14,483. Mounting metallic filaments and electrically soldering them in incandescent lamps (C.S.). I.C. July 8, 1907, Italy. S. Marietti, 72, Cannon Street, London.

II.—GAS LIGHTING.

13,648. Gas lamps. June 13, 1907. Accepted June 24, 1908. G. Helps, Izon's Croft, Ansley, Atherstone.
14,879. Inverted incandescent burner. June 29, 1907. Accepted July 8, 1908. J. H. Woodroffe, Clifton Villa, Finch Road, Handsworth, Staffs.

1,852. Incandescent mantles (C.S.). January 27, 1908. Accepted July 8, 1908. W. E. Lake, 7, Southampton Buildings, London. (From Akt.-Ges. Für Selas-Beleuchtung, Germany.)
3,055. Incandescent mantles (C.S.). I.C. Nov. 16, 1907, U.S.A. Accepted July 8, 1908. A. P. White, 28, New Bridge Street, London.
4,549. Inverted incandescent lamps (C.S.). I.C. May 1, 1907, Germany. Accepted July 1, 1908. M. Graetz and A. Graetz, trading as Ehrich and Graetz, 18, Southampton Buildings, London.
6,026. Incandescent mantles (C.S.). March 18, 1908. Accepted July 15, 1908. E. Ross, 56, Myddelton Square, London.
6,365. Gas-light pendants (C.S.). March 21, 1908. Accepted June 24, 1908. S. Chandler and J. Chandler, Birkbeck Bank Chambers, London.
6,468. Gas-mantles (C.S.). I.C. Aug. 10, 1907, U.S.A. Accepted July 8, 1908. P. R. Finch, 31, Bedford Street, Strand, London.
8,473. Gas pendants (C.S.). April 16, 1908. Accepted July 1, 1908. C. W. Kemp, 11, Burlington Chambers, New Street, Birmingham.
8,566. Inverted incandescent lamps (C.S.) I.C. April 18, 1907, Germany. Accepted July 15, 1908. Neue Kramerlicht G. m. b. H., 7, Southampton Buildings, London.
9,286. Nozzles for inverted incandescent burners (C.S.). I.C. Nov. 19. 1907, Germany. Accepted July 8, 1908, Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 1, Great James Street, Bedford Row, London.
9,760. Lighting devices for street lamps, &c. (C.S.), May 5, 1908. Accepted July 8, 1908. O. Schubert, 18, Southampton Buildings, London.
10,856. Igniting street lamps (inverted incandescent) electrically (C.S.). May 19, 1908. Accepted June 24, 1908. F. T. Cotton, 8, Quality Court, Chancery Lane, London.
12,318. Inverted incandescent lanterns (C.S.). I.C. June 8, 1907, Germany. A. Luber, 77, Chancery Lane, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

12,260. Combined electric and gas lamp (C.S.). I.C. May 25, 1906, Germany. Accepted July 8, 1908. H. A. Rhode, 6, Long Lane, Aldersgate Street, London.
14,551. Lighting and extinguishing lamps. June 24, 1907. Accepted June 24, 1908. A. T. Cowper-Smith, 4, South Street, Finsbury, London.
19,333. Portable lighting apparatus for indoor photography (C.S.). Aug. 28, 1907. Accepted July 1, 1908. J. Leclerc, 8, Quality Court, Chancery Lane, London.
25,695. Illuminated advertising devices (C.S.). Nov. 20, 1907. Accepted June 17, 1908. Radium-Licht-Reklame Co., m. b. H., and F. Stern, 6, Bank Street, Manchester.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.— Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

TRADE NOTES.

We have received from Mr. Würthrich, manager and chief engineer of the British Department of the Oerlikon Maschinenfabrik, an account of the 6,000 k.w. turbo-generators recently supplied by the company to the Stockholm Electricity Works. The generators supply power at a pressure of 6,000 to 6,500 volts, a frequency of 25, and a speed of 750 revolutions per minute, and are stated to have given every satisfaction.

Messrs. The Union Electric Co., Ltd., send us an advance copy of their list of Union Motors and Fortiter Motor Starters, including air- and oil-cooled starters equipped with no voltage and overload release.

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EDITORIAL.

The Ultra-Violet Element in Daylight and Artificial Light.

In the editorial remarks in the last few numbers we have drawn attention repeatedly to the inconsistency constantly encountered in the prevalent statements as to the colour and physiological effects of different illuminants. We have explained that such statements can serve no useful end unless they are backed up by the weight of scientific evidence and that definite conclusions on the points raised are not at present forthcoming.

The article by Dr. Nichols, which we abstracted in our last number, contained valuable information on the subject of the spectral composition of various illuminants and their deviation from daylight. Whatever view is taken as to the correctness of Dr. Nichols's conclusions, it must at least be recognized that the method of scientific investigation is the only one that can lead us to definite conclusions on these disputed points.

In our present number we have devoted special attention to several recent papers by Dr. F. Schanz, Dr. Voege, and others, on the subject of the ultra-violet constituent present in sunlight and artificial illuminants, and its physiological action. Here again, we can only express satisfaction at the scientific spirit of investigation in which the matter is approached, although in several cases the views taken by the authors are in apparent contradiction. Dr. Schanz, starting from the admitted cases of injury caused by sources rich in ultra-violet rays, proposes to employ a variety of glass which completely absorbs radiation of this nature. Dr. Voege, on the other hand takes the view that natural daylight, to the use of which our eyes have been gradually accustomed, is richer in ultra-violet rays than most artificial illuminants, and that the ultra-violet element in these sources must therefore be regarded as innocuous.

Yet it must not be supposed that because certain conditions occur in

nature therefore they are beneficial under all circumstances. Sunlight may be extremely rich in ultra-violet radiation, and it is certainly true that in nature we meet surfaces illuminated by the sun's rays which are far brighter than those encountered inside the home. But we also know for a fact that incautious exposure to the glare of the sun in tropical regions may cause serious injury to eyesight, especially in the case of people unaccustomed to these conditions. It is also highly probable that any one who attempted to gaze straight at the unclouded sun at mid-day constantly would go blind. Snow blindness, again, is now ascribed mainly to the injurious action of the ultra-violet rays prevalent in high altitudes.

The discussion which followed the reading of these two papers before the German Institution of Electrical Engineers serves to show that considerable importance is now attached to these questions, and a number of further researches are to be carried out in order to settle the points in dispute. To this discussion we mean to refer in a subsequent issue.

We have previously expressed the opinion that all these disputed questions affecting the influence of light on eyesight and hygienic aspects of illumination generally might well form the subject of an expert commission. Interesting confirmation of our conviction that the matter calls for authoritative Government control is afforded by the suggestion that has now been put forward in the United States that the Board of Health—an exceedingly active and influential body—should undertake to consider the framing of regulations affecting the hygienic aspects of illumination.

The Specification of Daylight-Illumination.

The article which Mr. Waldram contributes to the present number is an interesting commentary on a point to which we have repeatedly drawn attention, namely, the vital importance of the subject of illumination to the architectural profession.

Our previous remarks have frequently referred mainly to the æsthetic aspects of lighting, with which the architect is obviously concerned, but it must also be remembered that there are many legal and practical aspects of the subject which are at least equally vital to him.

One such question is the provision of adequate window-illumination in buildings, and the disputes that are constantly occurring with regard to ancient lights. Mr. Waldram draws attention to a number of obvious anomalies in the manner in which these questions are often decided. The value of actual measurement, as a means of deciding how far the available illumination in a room has been affected by an adjacent building, can hardly be questioned.

The whole problem of school-illumination, again, is very intimately bound up with the study of daylight-conditions, and we have previously dwelt upon the important work that may be done in this direction by architects who will give the subject scientific study. Daylight - illumination in schoolrooms is the more important on account of the fact that the vast amount of school work is done during the daytime. Moreover, many people have an unconcious feeling that, whatever may be thought of the artificial illumination in a room, the daylight-illumination can be safely regarded as sufficient and adequate unless, indeed, a fog is actually in progress.

As a matter of fact, it is frequently a matter of extreme difficulty to secure that all parts of a room receive even the minimum correct illumination by daylight alone, and it may safely be said that many schoolrooms in use to-day contain dark regions in which the illumination under which the children work is inadequate. The provision of daylight illumination is in the hands of the architect responsible for the arrangement of the window-space and

the scheme of decoration adopted. In this connexion Mr. Waldram remarks that it is only those architects with long experience behind them who are able to form some conception as to how far the arbitrary rules by which they are guided are applicable to local conditions. "Younger architects can only trust to guess-work and luck." He remarks, however, with some justice, that there has, until quite lately, been no recognized medium for the discussion of these matters and few suitable textbooks. This need 'THE ILLUMINATING ENGINEER' desires to supply, and we welcome discussion on this important subject.

Illuminated Notices in the Streets.

An article in the present number makes reference to one subject that may be commended to the notice of municipalities and those responsible for public lighting, namely, the provision of suitable illuminated notices and direction-signs in our streets.

We are only slowly emerging from a period of complete indifference to the needs of the stranger in this respect. It is no exaggeration to say that at one time the stranger within our gates was expected to determine his whereabouts and to know the names of streets by a species of instinct. Even to-day names are in many cases far from being as prominent as might be desired, and a point that deserves consideration from authorities is the fact that in many streets such names are quite as essential by night as by day, or even more so. They ought, therefore, to be suitably illuminated.

Apart from the names of streets and buildings, however, there are many instances in which special direction-signs are necessary, *e.g.* for the purpose of indicating the whereabouts of railway stations, &c., while the value of such signs from a purely business point of view is hardly yet sufficiently recognized in this country, in contrast with their great development in the United States.

At the same time there are indications that progress is being made in this direction. As an instance of the convenient use of luminous devices, we may mention those recently installed at the entrances to some of the tubes and those on the platforms of the Metropolitan and District Railway, calling attention to the destination of the next few trains due.

Companies supplying gas and electricity are also awakening to the increase in income to be derived from the extending use of illuminated signs for advertising purposes; and it may be anticipated that in the future they will form a very much more important feature of our streets than at present.

A Home for International Congresses.

AMONG other important forthcoming international events, we note with great pleasure that the International Conference on Electrical Units is to assemble in London on October 12th.

The present year has been signalized by a series of international rapprochements of a varied character, and on a scale that we have never encountered before. In London alone a score or more such congresses on various subjects have taken place, and it is safe to say that international action of this description is now no longer regarded as an act of grace, but also as a matter of the greatest scientific and commercial expediency. There is therefore every reason to believe that this tendency towards free interchange of ideas will continue, and we feel that the present moment is ripe for the organizing of congresses of this nature on a more definite recognized basis.

It is understood that, for the first time this year, a sum is to be set apart by the Government for the promotion of international hospitality. This commencement might well be extended to include one much-needed convenience to international meetings.

At the present moment such congresses have no definite meeting place. The members have necessarily to assemble in quarters of London selected

in a haphazard manner, and the building in which the meeting is held is often as inadequate for the purpose in view as it is difficult to locate. Surely when a number of distinguished visitors from other lands assemble in our country, the first duty confronting us is to make the details of the arrangements as simple and agreeable as possible. To this end it would effect a very grateful simplification if a conveniently situated hall were to be provided, specially adapted to the purpose in view and officially regarded as the meeting place of international congresses to be held in this country.

This hall might well constitute a national institution, worthy of the traditional hospitality of this great nation.

Naturally the illumination of the various rooms of such a building, whether libraries or devoted to the meetings of the congresses ought to receive particularly careful consideration, which cannot always be said to be true of the temporary quarters utilized at present.

An International Unit of Light.

Reference has been made above to a coming International Conference on Electrical Units. As we pointed out previously, the question of defining the units applying to the various quantities used in illuminating engineering still calls for international treatment.

In our present number we publish the first of a prospective series of articles dealing with the photometrical laboratories of different countries. On this occasion Dr. Hyde describes the arrangements and work carried out at the Bureau of Standards in Washington, U.S.A. One of our main objects in embarking on this series of articles is to provide a comparison of the methods used in different parts of the world for photometrical testing, and a review of the various problems presented for solution.

Dr. Hyde lays stress upon one matter which is rightly considered one of the most pressing subjects for international consideration, namely, the choice of a common unit of luminous intensity. An additional, closely related matter is the selection of common photometrical terms to denote the units of luminous intensity, intensity of illumination, &c.; and this point, it will be remembered, formed the subject of some controversy between M. Laporte and Dr. Monasch in our columns a short time ago.

A great deal of discussion has raged round the merits and disadvantages of the various standards of light used in different countries. Naturally it would be a great simplification if common primary and secondary standards of light could be agreed upon. A more vital matter, however, as Dr. Hyde points out, is the choice of a common *unit* in which the intensity of sources of light produced in all countries could be expressed. This question has recently received the joint consideration of the Institutions of Gas and Electrical Engineers and the Illuminating Engineering Society in the United States. The British, French, and American units approach each other so closely as to give little trouble, but the 10 per cent change required to bring the German unit into line is naturally a subject of some concern.

The advantages of agreement on this question are so evident that it can hardly be doubted that an international unit of light will not long be delayed. It is therefore all the more essential that nothing should be done to obstruct its coming by any incautious and hasty attempt at settlement by some body not possessing the necessary international representative character and the highest expert backing. The discussion between M. Laporte and Dr. Monasch previously mentioned afforded a valuable instance of the many-sided aspect that such problems present to the experts of different countries, and any attempt at settlement that is not representative both of different nations and different methods of illumination cannot achieve lasting success. LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter now enters upon the consideration of the subject of PHOTOMETRY, and discusses some of the methods that have been suggested for the direct measurement of light, such as those involving the use of photography and the Crookes radiometer. He also deals with the class of instruments known as "discrimination photometers," and explains the principles employed by Fleming, Houston and Kenelly, and others in order to utilize visual acuity as a basis of measurement of illumination.

Dr. C. V. Drysdale, having completed the instalment of his series of articles dealing with the mechanical equivalent of light, embarks upon a discussion of the LAWS AND MEASUREMENT OF RADIATION. He describes, with illustrations, a number of the early attempts to measure the energy of radiation, such as the solar radiation thermometer, and other devices, and the radiometer of Nichols.

Prof. J. T. Morris contributes the results of a comprehensive series of photometrical tests upon the most RECENT TYPES OF FLAME ARC-LAMPS, which he compares with those obtained for some incandescent gas-lights, and described in the last number of *The Illuminating Engineer*. A feature of the article is the complete series of diagrams of polar curves of the different lamps described, which are supplemented in each case by diagrams showing the exact nature of the carbons used.

Prof. H. Bohle, of Cape Town, gives the results of some EXPERIMENTS ON NERNST, CARBON, AND METALLIC FILAMENT GLOW-LAMPS, with the object of comparing their relative sensitiveness to fluctuations in P.D. He illustrates his results by the aid of an actual chart of the pressure supplied, and works out the relative cross-sections of cables required for a building suitably illuminated by each of the varieties of lamps studied.

Mr. P. J. Waldram, F.S.I., deals with the MEASUREMENT OF ILLUMINATION FOR ARCHITECTURAL PURPOSES. He gives a résumé of the existing legislation bearing on the subject, chiefly relating to the window-space for a given floor area. Such conventional rules as exist, however, he regards as inadequate to secure proper illumination, and advocates actual photometric measurements. Apart from the obvious desirability of being able to predetermine illumination in a building, such exact measurements would be of value in settling disputes about ancient lights which are a fruitful source of legislation.

The **Special Section** in the present number is occupied by a contribution by **Dr. E. P. Hyde,** who describes the PHOTOMETRICAL ARRANGEMENTS in use at the BUREAU OF STANDARDS, WASHINGTON, U.S.A. This is the first of a series of articles to appear, dealing with the chief photometrical laboratories of different countries. In addition to a complete description of the character of the work done at the Bureau, and the chief points of interest in the apparatus employed, Dr. Hyde lays special stress on the question of standards and units of light, and explains how the relations between the units in use in various countries are now continually checked by the interchange of carefully calibrated incandescent lamps.

The next step is for the various countries to decide upon a common average unit, even though each country may prefer to utilize its own standard, and this seems quite feasible in the case of Britain, France, and the United States, whose units approach each other so closely

Among other articles in this issue may be mentioned that dealing with

LIGHT AS A MEANS OF ATTRACTING ATTENTION. The author shows how, in daily life, the contrast between light and shade of objects and their surroundings is effectual in making the former "stand out" and attract attention. This principle is naturally not without effect upon the arrangement of light desirable in a reading-room or lecture-theatre. It is likewise worth consideration in the arrangement of shop-windows and illuminated signs in the streets. In the latter connexion the author suggests there is a great field for the more liberal use of direction-signs that are adequately illuminated.

Special reference is also made to the effect of light upon eyesight. This matter is now receiving a considerable amount of attention. In an article entitled SOME EFFECTS OF LIGHT, VISIBLE AND INVISIBLE, the author quotes instances to show how marked physiological effects of light may be taking place without our being aware of them. Attention is drawn to the series of discoveries relating to the effect of ultra-violet light upon the eyes and the skin as exemplified by the work of Finsen, and the effect of such rays on small-pox patients.

The papers by **Dr. F. Schanz** and **Dr. K. Stockhausen** and **Dr. Yoege** deal more particularly with the degree of ULTRA-VIOLET LIGHT IN ARTIFICIAL ILLUMINANTS. **Drs. Schanz** and **Stockhausen** quote instances of the injurious action of such rays, and advocate the use of a special variety of glass in order to absorb them. The value of this glass for the purpose is illustrated by a series of photographs of the spectra of illuminants, both with and without the "Euphos" glass.

Dr. Yoege, on the other hand, quotes experiments comparing the intensity of the ultra-violet in artificial illuminants with daylight. He comes to the conclusion that the proportion of radiation of this description is greater in the latter case. Yet our eyes have been gradually developed in order to use daylight, and it has not been found necessary to use glasses to eliminate the ultra-violet radiation occurring in it.

The papers by **Dr. H. Seabrook** and **Dr. Krall** are likewise concerned with the influence of artificial light on the eye, though in this case it is the injurious effect of intrinsic brilliancy that is mainly insisted upon.

Under the title WHAT IS LIGHT? we include some speculations by **Mr. P. G. Nutting**, regarding the physiological basis of vision and the part played by those minute organs on the retina, the "rods" and the "cones"; Mr. Nutting suggests the possibility of collecting these physiological effects and reprinting them by some standard series of formulæ.

Among other articles on varied subjects in this number we may draw attention to that dealing with the ILLUMINATION OF THE SINGER BUILDING IN NEW YORK. A portion of this building consists in a very high tower, which is illuminated from without by the aid of searchlights and concealed glow-lamps, instead of the conventional system of "outline-lighting."

Some results of TESTS ON ACETYLENE-BURNERS are also given, and also an account of an ingenious device for improving the performances of incandescent burners. A résumé is given of a report recently issued by **Mr. Frank Sumner** on the COST OF THE LIGHTING OF LONDON STREETS.

Mr. Chas. Baker also contributes a letter to our correspondence columns dealing with the subject, and suggesting the desirability of extending such experiments as those undertaken by Mr. Voysey, so as to include a larger area.

Mr. Lancelot Wild writes commenting upon the article by Prof. J. T. Morris occurring in our last number, and urging the necessity of specifying the conditions under which gas-burners are stated to give certain results. At present, owing to fluctuations in pressure, uncertainty as to quality of gas to be used with burner, and other causes, it is difficult to predict what its exact performance will be.

At the end of this number will be found the usual **Review of Current Literature dealing with Illumination** and the **Patent List.**

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 625.)

Photometry.—Photometry, or the measurement of light and of illumination, differs in several respects from other physical measurements; and before discussing practical apparatus and its use, it is well to give some consideration to the limitations to which photometry is subject. The idea of measuring light is so unfamiliar to many quite intelligent people, that they confuse the word photometry with photography, and have neither the remotest idea that light can be measured nor how any operation of measurement can be carried out when no units of length, volume, weight (for such people do not understand mass in its scientific sense), or time, or appreciable force or movement enter into the question.

There is an important branch of physical science which deals with the objective action of light. This department of the science of optics is concerned with the generation of luminous radiation, its transmission. refraction, reflection, polarization, and so on; it deals with dynamic and geometrical considerations, either as pure abstractions or assisted, illustrated, and guided by experiment.

Photometry, in the original sense of the word, as used by Lambert in his treatise 'Photometria sive de Mensura et Gradibus Luminis colorum et umbræ,' published in 1770, was not so much experimental as deductive. Lambert started with such axioms as "Two candles give more light than one," and he developed theorems like Euclid. He used experiments chiefly to illustrate theorems and to verify laws, but he also discovered facts. Some writers have attributed to Lambert the invention of the photometer generally known as Rumford's, but at the beginning of 'Photometria' he discussed at some length the desirability for a photometer, and regretted that no such instrument had been invented. Summing up the discussion in a passage in italics, he said that the eye lacks an instrument analogous to a thermometer. This statement is remarkable, for he describes several experiments in which he actually employed photometric methods.

Photometry in its modern sense is mainly experimental, and the term is hardly applicable to the foregoing section of these articles, which, with the exception of the description of the standards of light, has been of a deductive character.

Photometry differs from those other sections of optics to which reference has been made in that it depends upon the subjective effect produced by the stimulation of a special organ of sense. Whatever results we obtain, however ingenious the apparatus used to arrive at them, and whatever the conditions we prescribe for carrying out the work, our measurements are of no value if they disagree with the commonsense estimate which any-

body may make by merely using his eyes.*

If the results of photometry yielded nothing more than an agreement with that commonsense estimate, the labour would be in vain. Allusion was made on p. 8 to the inability of the eye to judge the candle-power of a lamp or the relative candle-power of two sources of light with any degree of accuracy. By means of a photometer the relative candle-power may be measured with little difficulty to 2 per cent, and by taking suitable precautions, and after some practice, and under favourable conditions, an accuracy of half of 1 per cent may be obtained. There is no disagreement here, but a development of our powers.

Photometry is not the measurement of an external or objective dimension or force, but of a sensation. It is difficult to make a quantitative measurement of our sensations. Two pigs under a gate make more noise than one pig, and while it is possible to measure the amplitude of the vibrations of air which produce sounds, and to estimate those which correspond to the faintest audible sound and those which cause the roar of a large organ, we know little of the quantitative measurement of sound. The attempt to apply measurement to sensations of smell has not met with success, and in spite of the delicacy with which different sensations of taste may be discriminated, it not only seems impossible to measure taste, but there appears to be physiological reasons for a rapid approach to a saturated condition of the sensation. A similar difficulty arises in the action of light on the eye.

Most physical measurements depend upon the observation of the relative position of parts of an apparatus, such as an index and a scale. The mistake is sometimes made of supposing that because photometers generally have an index and a scale, there is a direct connexion between the quantity so indicated and the quantity to be measured. The quantity indicated is generally a length, or in the case of certain photometers an angle, though in fact this is only the use of a graduated circle instead of a graduated straight line. The quantity to be measured is the physical intensity of a luminous radiation. The connexion between these is a psychological quantity, and this again depends upon a physiological function.

With the exception of a class of photometers which depend upon the faculty for discriminating the small detail of a pattern or for reading printed matter, all others depend on the judgment of the eye for judging the equality of, or for detecting a small difference between the illuminations of two screens or parts of a screen.* This is surrounded by physiological complications even when the illuminations are of the same colour, but when the colours differ new difficulties arise, and von Helmholtz has declared that no comparison worthy of being called a physical measurement can be made between lights of different colours, on the ground that the sensations are heterogeneous. It is true that with ill-devised apparatus and unsuitable methods some difficulties are experienced, but the judgment that two surfaces of different colours are of equal or of unequal brightness is an operation with which every artist in black and white or monochrome, and every engraver and etcher is familiar.

At the time when the paper of which these articles are an expansion was written,† photometry had been confined chiefly to the commercial testing of gas, and a few scientific researches such as those of Sir W. de W. Abney and General Festing. As a department of physical science the subject does not seem to have been very attractive, probably because it is one of the least accurate kinds of measurement. Many attempts have been made to banish visual photometry altogether from the physical laboratory. At one time it was thought that the radiometer would supplant it, but it was soon found that the

* "In definiendis luminis gradibus solus oculus est judex."—Lambert, 'Photometria,' p. 6.

* "Non tamen inter gradus claritas aliam dignoscere valet rationem præter rationem æqualitatis."—Lambert, 'Photometria,' p. 16.

† May, 1892.

rotation of the "light-mill" depended on thermal rather than on luminous rays. The thermopile and the bolometer have been used to measure the whole radiant energy by means of electrical apparatus, and the dark heat rays or the luminous rays have been filtered out by selective absorption. Considerable accuracy is possible with such methods, but even if by great precautions changes of temperature have been avoided, and unsuspected radiation of heat guarded against, the proportion of luminous energy to thermal energy is so small that it is hopeless to arrive at any precise measurement of light alone. Photometers proposed by Dessendier and by Lion, depending on chemical combinations of gases, may also be dismissed either as insufficiently developed or as unsuitable for practical purposes; and although from time to time the electrical properties of selenium give some promise of quantitative indication of the intensity of light, nothing with a pointer or an index such as Lambert wanted has been produced which can compete with an ordinary visual photometer, or enable a standard of light to be dispensed with.

There is a danger in all these electrical and chemical methods of measuring something that is not light. "Radiant heat and light," said Lord Kelvin,* "are one and indivisible. There are not two things, radiant heat and light; radiant heat is identical with light.... It is light if you see it as light; if it is not light you do not see it.... Radiant light is light if we see it, it is not light if we do not see it."

Photographic methods have been suggested; daylight and sunlight have been investigated by Sir W. Roscoe,† and under certain circumstances useful results might be obtained.

It was stated on p. 183 that an exposure of about 5 foot-candle seconds gives a sensitive shade of grey on "slow" bromide paper. This might be used for integrating or averaging the whole illumination of a street by carrying a strip of such paper about in a systematic manner for a definite time over a definite area.

I have exposed in a street such a strip to an illumination of about 1 foot-candle for 5 seconds and another strip from the same sheet was exposed at home, also for 5 seconds, to different illuminations, namely, 0·8, 0·9, 1·0, 1·1, 1·2 foot-candle. The two strips were then developed together in the same dish. This gave a number of bands of different tone, forming a scale, and the tone of the test strip could be compared with this scale, and its value estimated. The development of a number of strips can be quickly carried out, and, like indicator diagrams, they afford a permanent record of the measurements. But a considerable number of precautions would have to be taken, and in order to avoid differences of actinic power, selective filters or screens would have to be used. It would, indeed, be necessary to do more than this; screens would have to be used so that the measurements represent the effective or useful illumination as judged by the eye.

Discrimination Photometers.—Before entering on the discussion of photometers which depend upon the balancing of two equal illuminations, two classes of photometers based on the power of the eye to discriminate small details may be described.

Long ago, before any practical standards of light had been proposed, instruments had been used for estimating visual acuteness under various conditions, such as different degrees of illumination and various coloured lights. Printed slips or black-and-white patterns were used by Celsius, the Swedish astronomer, in 1735, apparently for the purpose of photometry. "He made it depend upon the distinctness with which we observe very small objects at different distnaces, in accordance with their greater or less illumination, and he did not take into account that it was even more difficult to reduce this distinctness to a certain law than it would be to measure the actual

* Kelvin, 'Popular Lectures and Addresses,' vol. i. p. 291.

† *Proc.* Royal Society, Bunsen and Roscoe, 1862, p. 139, and Roscoe and Brennand, vol. xlix. Dec. 11, 1890; Richardson and Quick, *Phil. Mag.*, vol. xxxvi. 1893, p. 459.

force of the light. He maintained that, to see some small object of an equally distinct manner at twice the distance, it must be illuminated 256 times more, in accordance with the eighth power of the distance: but it is certain that if a very short-sighted person reads with facility small letters at 4 or 5 inches in a dim place, there is no light in the world which could made him decipher them at 14 or 15 inches, unless his eyes were of a most extraordinary kind."* Buffon and Sir W. Herschel employed the same device.

In 1895 the idea was revived by Profs. E. J. Houston and A. E. Kennelly. At that time the inventors were unaware of the existence of any illumination photometer except that of Prof. L. Weber which will be described later. Their instrument† consisted of a small oblong box containing a test object of small printed type at one end (A Fig. 45) and a focussing eyepiece B at the other. One side of the box was provided with an opal glass window C, over which a sliding shutter D could be moved.

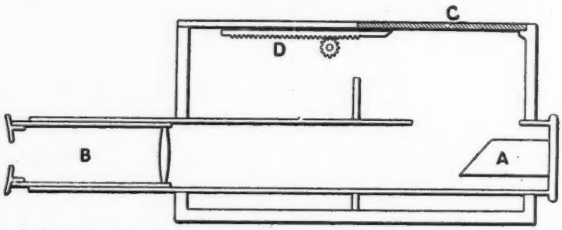


FIG. 45.—Houston and Kennelly's Photometer.

The shutter controlled the lighting of the test object, and an index moving over a graduated scale was used to give the value of the illumination. To make a measurement the window was placed to receive the illumination, and the shutter was moved until the test object was only just legible. The inventors asserted that "a certain intensity of illumination is required to render a definite object, viewed at a definite distance, clearly delineated to the eye." The focussing eyepiece was claimed to annul "the effect of any focal abnormalities of vision." The average deviation of any measurement from the mean of a number of measurements was modestly put at 10 per cent, and the results of different observers did not appear to differ more than this. The scale was, of course, graduated by experiment, and it was proposed to use it for candle-power photometry as well as for the measurement of illumination. The unfortunate name "illuminometer" was given to the instrument, and it is to be regretted that this mongrel word is sometimes used at the present day.

There is another class of discrimination photometer which must not be confused with the one which has been described. The first class endeavours to dispense with a standard source of light and to measure illumination by diminishing it in a known proportion until the test object cannot be distinctly seen; the second class endeavours to compare two different illuminations with reference to their power of revealing small details. The condition of minimum visibility has nothing to do with this. Ritchie applied this principle to the photometer which will be described.

More than fifty years ago Mr. Sugg used printed test slips for street photometry. He did not attempt to use the minimum illumination at which it was possible to read, but he used two slips, one was exposed to the illumination to be measured, and the other to a standard lamp.

In photometric work in the streets and public buildings of London in 1891–2 I occasionally read a Bradshaw,

* Bouguer, 'Traité d'Optique,' p. 48. Referred to also in Bouguer, 'Mem. de Math. et de Physique Ac. des Sci.,' 1757.

† Fully described in *The Electrical World*, New York, March 9, 1895.

or the small type of Bellew's French Dictionary, rather for the purpose of trying whether any difference could be found by such a test, when illuminations due to electric arc-lamps and gas-lamps were the same as measured on a photometer. I found no perceptible difference.

Dr. J. A. Fleming has experimented in this direction. He has prepared* by photography test objects consisting of black or white dots one-fifteenth of a millimetre in diameter, or parallel lines of that width. At a distance of 10 in. from the eye, these have an angular magnitude of one minute.

He attaches these photographed patterns to the sides of a wedge W, Fig. 46. The lights to be compared are in the directions A and B. The wedge is observed through a diaphragm in the eyepiece E. No lens is used, but the hole in the diaphragm is only 1 mm. in diameter. The object of this small hole is to restrict the light to a beam smaller than the size of the pupil of the eye. This prevents the expansion of the pupil when the eye is directed to the dimmer side of the wedge, and its contraction when the brighter side is looked at. Experiment showed that the detail-revealing power of four candles at 2 ft. and nine candles at 3 ft. and one candle at 1 ft. are practically the same. It was found that when an arc-lamp was used, the detail-revealing power of the light was rather less than its brightness, producing power. The difference appears to be slight, and this warrants the use of ordinary and more accurate illumination photometers for practical work.

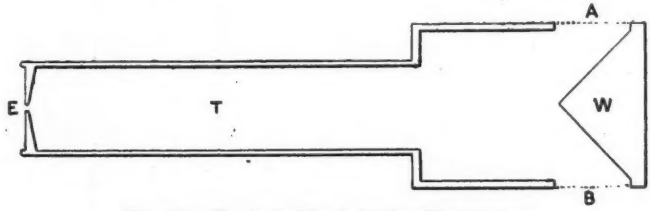


FIG. 46.—Fleming's Discrimination Photometer.

The use of instruments of the first class such as that of Profs. Houston and Kennelly in an anthropometric or psychological laboratory would seem to be natural, for the purpose of testing and comparing the keenness of vision of different individuals, or of one individual under different conditions. The second class, if used with great care, and having regard to the physiological conditions of vision through eyepieces, might be of some use in estimating whether ordinary photometers yield comparable measurements of illuminations when they are produced by different coloured lights or by sources of light of widely different intrinsic brilliance.

One of the first symptoms of failing sight is the difficulty of reading small print with a feeble illumination. This is experienced when the optical properties of the eye seem to be still so good that no lens can improve the focussing power. The chief reason seems to be that with a good illumination the aperture of the pupil is contracted, and this, by "stopping down the lens," gives a sharp image on the retina which cannot, perhaps, be improved by the help of a lens. But with feeble illumination the iris expands, and since with old age the power of accommodation (that is to say, the muscular control of the lens, and to a certain extent of the iris also) is diminished, the image is ill-defined. This action of the iris must be distinguished from "focal abnormalities of vision," and cannot be annulled, as Profs. Houston and Kennelly suggest, by a focussing eye-piece, but can be dealt with by the small hole used by Dr. Fleming.

(To be continued.)

* Fleming, *Journal Inst. Electrical Engineers*, vol. xxxii. p. 156 *et seq.*

The Production and Utilization of Light.

The Laws and Measurement of Radiation.

By Dr. C. V. Drysdale.

(*Continued from p. 644.*)

It cannot be too clearly kept in view, in all questions concerning the production of light, that this light is merely one portion of that form of energy which travels through space as waves in the ether, and is called radiation. Our object in seeking for more efficient sources of light is to find a means whereby as large a proportion as possible of their radiation shall be in the form which is of use to us in rendering objects visible; but for this purpose a knowledge of the laws relating to radiation of all kinds, visible and invisible, is of the greatest value. In fact it may be claimed

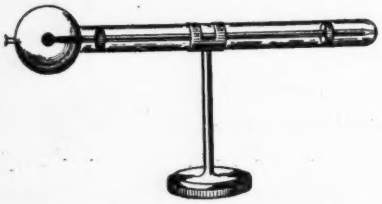


Fig. 1.—Solar Radiation Thermometer.

that practically the whole of the improvements in lighting which have recently taken place have been due to steady investigation of the laws of radiation and the application of these laws to practice; and it may be predicted that further advances will have to be made along the same lines.

Before dealing with the laws of radiation reference may be made to the various devices by which radiation may be detected and measured. Such devices are of value not only for actual radiation measurements, but in connexion with pyrometers for high temperature measurement. Putting aside those which deal with electromagnetic waves of comparatively low frequency, such as Hertz resonators, coherers, &c., we have several which serve for the detection and measurement of heat and light radiation with which we are most concerned.

One of the earliest and simplest detectors of radiation was the blackened bulb thermometer, which is still used for the estimation of the intensity of

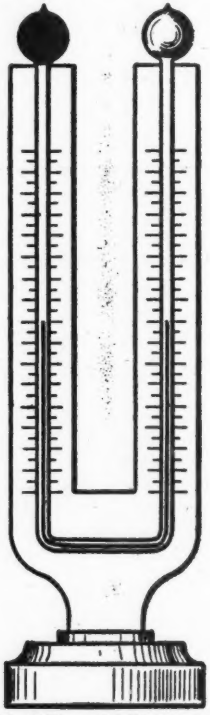


Fig. 2.—Differential Thermometer.

solar radiation. Fig. 1 shows the ordinary solar radiation thermometer, consisting of a mercury thermometer with lampblack-covered bulb, enclosed in an outer exhausted glass bulb, which avoids cooling by air currents.

A much more sensitive form of

radiation measurer is the differential thermometer shown in Fig. 2. Here two similar bulbs of fairly large capacity are connected by a U-tube containing a liquid. If the pressure in the two bulbs is the same, the level of the liquid is the same in both tubes, but if one of them is blackened, and radiation falls upon the instrument, it is absorbed by the black coating, thus heating the air in the blackened

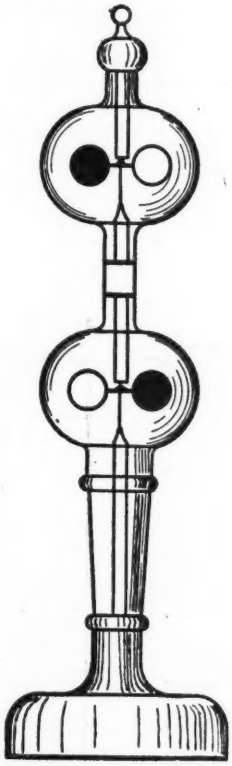


FIG. 3.—Crookes Radiometer.

bulb and causing a depression of the liquid on that side. Such an instrument is unaffected by the external air temperature, which acts equally on both bulbs, and the difference between the level of the liquid on the two sides, therefore, only depends upon the intensity of radiation.

A larger and more sensitive form of air thermometer was employed by Tumlirz in 1888* when making his determination of the mechanical equivalent of light referred to in the last chapter. It consisted of a metal cylinder with horizontal axis 40 mm. in diameter by 50 mm. in length, one end of which was blackened and the other communicated with a long vertical tube to a reservoir. The metal cylinder was enclosed within another, 48 mm. diameter and 62 mm. long, the front end being glazed with a

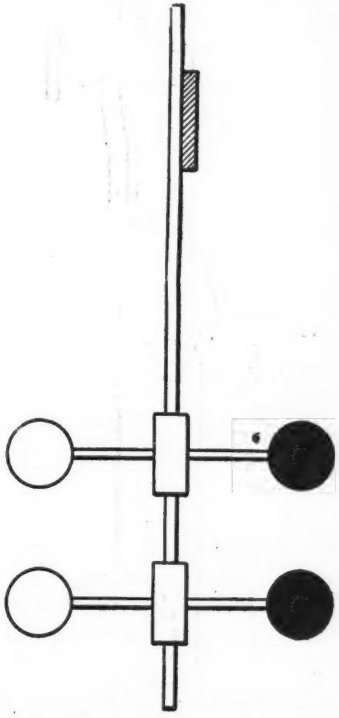


FIG. 4.—Lebedew's Suspended System.

window of rock salt 4 mm. thick, through which the radiation entered.

Although not so frequently used, one of the simplest and most sensitive detectors of radiation is the so-called radiometer of Sir Wm. Crookes. The absorption of radiation produces a pressure of magnitude equal to the energy contained in unit volume of the medium, and in consequence, if a

* 'Sitzungsber. der Kais. Akademie der Wiss. Wien,' Band XCVII. abth. IIa, p. 1523.

vane with one of its surfaces polished and the other blackened is suspended in a vacuum tube where it is unaffected by air movements, the blackened surface will be repelled. In the ordinary "radiometer" (Fig. 3) these vanes are simply pivoted lightly, so that they revolve rapidly when radiation falls on them, but if a single vane is suspended by a fibre and provided with a small mirror it turns through an angle proportional to the intensity of radiation, and forms a true radiometer (Figs. 4 and 5). This device was employed by Lebedew in his investigation of the pressure of light, and by Drew and Geer in measuring the radiant efficiencies of vacuum tubes and the mercury vapour lamp.

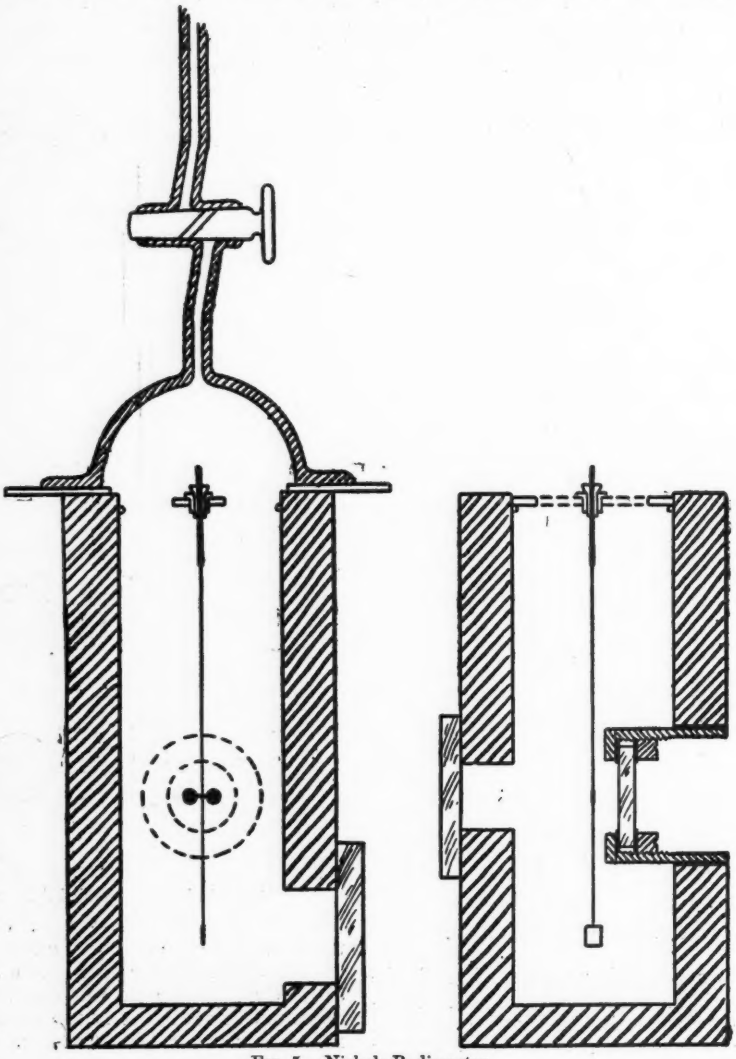


FIG. 5.—Nichols Radiometer.

(To be continued.)

Tests of Recent Flame Arcs.

By J. T. Morris, M.I.E.E.

Professor of Electrical Engineering at the East London College.

In an article on 'High and Low Pressure Incandescent Gas Lighting,' which appeared in this journal last month, the author gave the results of some recent tests on incandescent gas lamps made with the object of comparing the two kinds of illuminants—gas and electricity. In this article are collected results obtained for the second of these illuminants, *i.e.*, electricity.

The method of testing was identical with that used in the case of the incandescent gas tests described in the article previously referred to, the polar diagrams being obtained by the help of a pair of movable oval mirrors.

The following is a list of the lamps tested :—

Crompton-Blondel.—Crompton & Co.

Excello.—Union Electric Co.

Gilbert A.C. and D.C.—Gilbert Arc-Lamp Co.

Jandus (enclosed).—Drake and Gorham.

Jandus Flame (enclosed).—The Jandus Arc-Lamp and Electric Co., Ltd.

New Century.

Oriflamme A.C. and D.C. — The Oliver Arc-Lamp Co.

Westinghouse. — British Westinghouse Electric and Manufacturing Co.

The author would like here to express his cordial thanks to all the firms who have so kindly supplied these lamps, and have given help in many ways, including expert personal assistance. His thanks are also due to Mr. W. C. P. Tapper, and, in connexion with the Jandus flame-lamps, to Mr. A. Denman Jones, who has given him valuable help.

All the lamps tested were run for a period of not less than half an hour under normal conditions before any measurements were made for the tests recorded, and in practically all cases the two or more tests made on the same lamp were carried out on different days, the lamp in the interval having been taken down and rehung. In each case two complete polar diagrams were taken for each lamp, one exception only being made, that of the Oriflamme A.C. lamp. For this lamp the results were so consistent, that no further test was deemed necessary. On the other hand, in a few cases three, or even more, tests were made to ensure that the results obtained should be representative of the individual lamp under test. If, for instance, there was any reason to believe that the performance of the lamp during test was in any way unusual, a third test was made at a later date.

It will thus be seen that considerable care has been exercised to ensure fair conditions for each lamp while under test. It should, however, be borne in mind that the total luminous flux per kilowatt given out by a lamp is by no means the sole criterion by which to judge a lamp from the commercial point of view, because, apart from questions of efficiency, kind of globe employed, and polar distribution, there are matters of even greater moment, such as robustness of construction, simplicity of working parts, steadiness of light, length of burning hours, and initial cost of the lamp.

Each lamp was tested with the globe, and also the shade which the manufacturers provided in position. The globes supplied differed so greatly in opacity, that an attempt was made to determine approximately the absorption of light by the various globes.

At first sight the most direct method would appear to be to obtain the polar diagram for each arc first with the globe and then without it, and from the increase in candle-power

deduce the absorption of the globe. But this method is open to two serious objections — (1) that the absence of the globe very often causes the light to flicker badly, and (2) the carbon consumption may be appreciably increased and an actual change in the candle-power emitted by the arc and carbons result from air getting at the arc more freely than when the globe is in place. It is also obvious that in the case of enclosed arcs this method is impossible.

In connexion with this matter the results given by Dr. Marchant in the June number of this journal are of considerable interest. He there states that the mean hemispherical candle-power of a particular flame-arc was reduced from 2,650 candles to 360 when the globe was put on, the watts being 380. This means that the light was reduced to less than 14 per cent, *i.e.*, an absorption of over 86 per cent; and in another case is mentioned an absorption of even 90 per cent. It is probable, however, that the mean spherical candle-power, as distinguished from the mean hemispherical candle-power, would not be altered to such a considerable extent, owing to the alteration in the light distribution, brought about by the use of a dense globe.

To overcome the difficulty referred to above a method giving only approximate results had to be adopted. The candle-power of a carbon filament glow-lamp was measured first directly, and then when centrally hung in each of the globes, and the resulting diminution in candle-power thus obtained. This gave an approximate measure of the absorption of the globe.

The method is, however, open to criticism on account of the fact that the light emitted by the arc has a spectrum differing widely from that of the glow-lamp, and in a lesser degree to the fact that the polar distribution is altered, and it is conceivable, and, indeed probable, that the absorption in the two cases would be different. By way of testing this point a "sun" tantalum lamp was used in place of the carbon filament lamp, and practically the same coefficients were obtained, hence a fair degree of reliance may be placed upon the accuracy of these coefficients.

An attempt was made to determine the various degrees of absorption of the globes for different coloured lights by means of a spectroscope, but although diminution was noticeable in the light intensity in certain parts of the spectrum, it was not sufficiently marked to allow of a quantitative use of the observations.

The following table (Table I.) gives a summary of the absorption tests:

TABLE I.

SUMMARY OF TESTS OF APPROXIMATE ABSORPTION OF GLOBES, JULY, 1908.

Name of Lamp.	Fraction of Light passed by Globe.	Percentage Loss.	Remarks.
Westinghouse ..	·6	40	Horizontal beam
	·57	43	Beam at 45° downwards
Crompton-Blondel	·57	43	Horizontal beam
	·57	43	
	·62	38	Horizontal, but direction at right angles to previous measurement
Oriflamme A.C. ..	·6	40	Horizontal beam
A.C. ..	·646	35·4	Beam at 45° downwards
A.C. ..	·67	33	
D.C. ..	·67	33	Horizontal beam
Gilbert D.C. ..	·77	23	Horizontal beam
,, ..	·78	22	Horizontal (but 90° to preceding)
A.C. ..	·77	23	Horizontal beam
,, ..	·70	30	Horizontal (but 90° to preceding)
cello D.C. ..	·66	33	After long run
,, ..	·71	29	Freshly cleaned
another globe	·79	21	,,
	·69	31	Not cleaned
New Century 15 amp. globe ..	·78	22	
,, ,, ..	·71	29	
,, ,, ..	·77	23	
10 amp. globe ..	·85	15	
	·895	10·5	
	·816	18·4	
Jandus Flame ..	·842	15·8	Lets thro' yellow light
,, ,, ..	·845	15·5	
,, Ordinary Opal	·715	28·5	
,, ,, ,,	·74	26	
,, Ordinary Plain Glass.. ..	·92	8	
	·915	8·5	
	·884	11·6	

it will there be noticed how much the same globe may differ in its absorption in different directions. It is also worthy of note that considerable differences often occur in the absorption of a number of globes supplied in the same batch, a variation in the coefficient

of absorption of from 15 to 25 per cent being quite common.

It is singularly difficult to judge by eye of the relative absorption of different kinds of globes. An opalescent globe with a faint milky appearance in the glass may cut off twice as much light as a globe looking much more opaque, but more of the ground glass type such as the Jandus globe. The actual figures obtained in these are from 22 per cent to 30 per cent for the former, and from 15 per cent to 16 per cent for the latter.

The lamps fall naturally into four groups, as follows :—

Ordinary arcs open.
" " enclosed.
Flame arcs open.
" " enclosed.

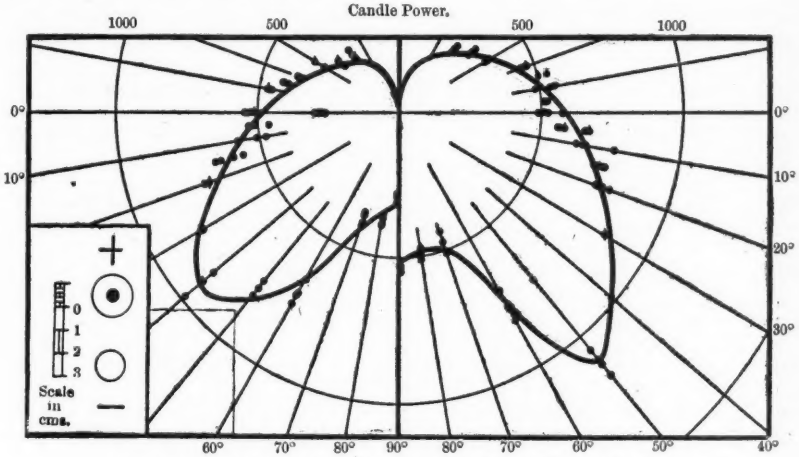


FIG. 1.—New Century Direct-Current Open Ordinary Arc (15 amp.).

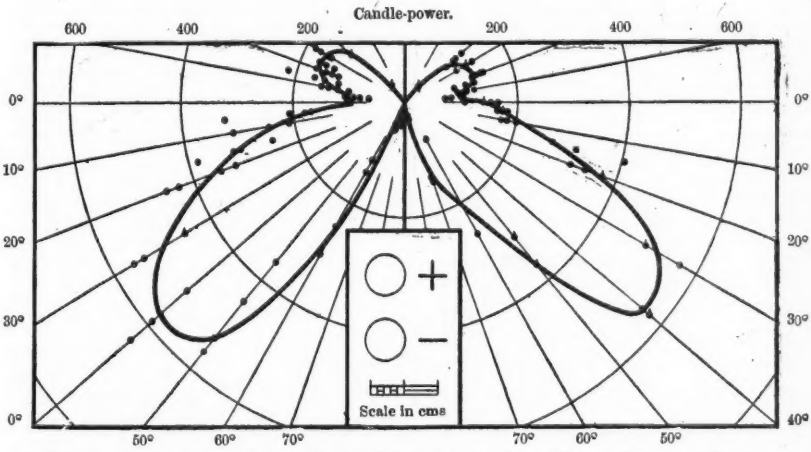


FIG. 2.—Jandus Direct-Current Enclosed Arc (5 amp.) clear Globe and Inner enclosure.

ORDINARY ARCS (OPEN).—The only example of this type tested was the New Century. This lamp was taken as a fair example of the ordinary open type of arc, being considerably used for street lighting. It had a cored positive carbon for the top and a solid carbon for the lower—these being

arranged directly one above the other. In Fig. 1 are given the polar diagrams for the two tests. Here it should be mentioned that throughout the tests not a single observation taken has been discarded, but all appear on the diagrams.

The method of taking the observations was in general to take them every 5 degrees from 20 degrees above to 20 degrees below the horizontal, and other observations every 10 degrees, four consecutive observations being taken at each point; and generally the more important parts of the test were repeated near the conclusion of the experiment. The method of indicating the observations on the diagrams is as follows: one observation thus ●; two observations falling on the same spot thus ◉; and three or more thus ✱.

A scale drawing of a section of the two carbons used is shown with each diagram, where the pure carbon is shown in white, and the core, impregnated or otherwise, in black. The small black dots indicate the position of the wire, which is used in some long thin carbons.

ORDINARY ARCS (ENCLOSED).—The lamp tested was a Jandus ordinary enclosed, which was made seven years ago. It had a clear inner enclosure and outer globe, and the usual solid carbons—top and bottom—of the same size. The polar diagrams are given in Fig. 2.

FLAME-ARCS (OPEN)—(axial carbons).—A Crompton-Blondel was the lamp tested of this class. In this lamp the positive carbon is the lower, and consists almost entirely of core; the negative being the upper carbon, and having a small core of more usual proportions. This carbon protrudes a short distance through a flat plate, upon which a white deposit settles very shortly after putting the lamp into operation, and thus serves as an excellent reflector.

The colour of light emitted by these carbons is in the author's opinion the

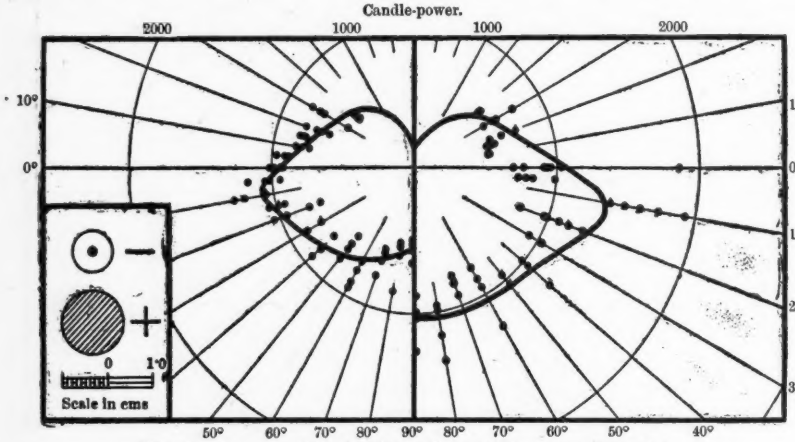


FIG. 3.—Crompton Blondel Direct Current Flame Arc (10 amp.).

closest approach to an ideal artificial illuminant, and it is to be hoped that the constant slight flickering of this lamp may in time be obviated. The polar diagrams for this lamp are shown in Fig. 3. As was mentioned in the previous article, either a Wild flicker photometer or a grease-spot photometer were used in all the photometric measurements; and in the tests with this lamp more experience was required to use the flicker photometer satisfactorily owing to the rapid fluctuations of light which occur in the normal operation of this lamp. The lamp was supplied with a single large globe, which was rather opaque, and the supply of air to the lamp fixed by the manufacturers by the

adjustment of the size of certain apertures.

FLAME-ARCS (OPEN) (inclined carbons).—The lamps of this class which were tested were Excello D.C., Gilbert D.C. and A.C., Oriflamme D.C. and A.C., and the Westinghouse. The polar

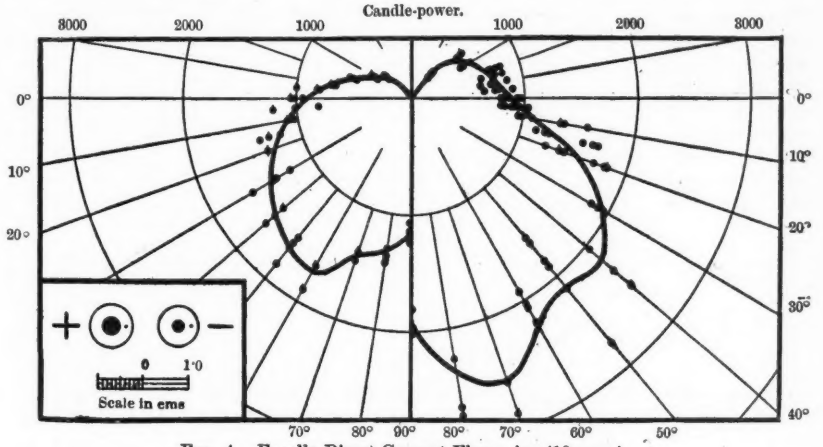


FIG. 4.—Excello Direct-Current Flame Arc (10 amp.).

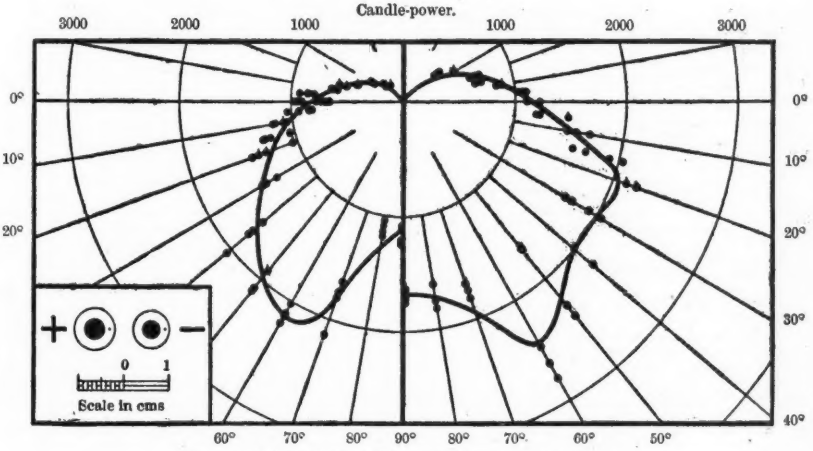


FIG. 5.—Gilbert Direct-Current Flame Arc (10 amp.).

fritter away far more slowly than in lamps of the open type, and hence have devoted a considerable amount of time to developing a flame-arc which should be enclosed. The saving in the consumption of the more costly flame carbons and consequent increased

diagrams—Figs. 4, 5, 6, 7, 8, and 9—relating to these lamps speak for themselves.

FLAME ARCS ENCLOSED.—Many experimenters have been attracted by the fact that carbons in an enclosed lamp burn, or, to speak more correctly, length of burning hours being the attractive features. On the other hand there are many difficulties to surmount, in order to obtain a commercially satisfactory enclosed flame arc. Chief among these is the dense deposit which flame carbons produce, and

next to this the increased unsteadiness of the light itself.

The lamp of this type tested was the Jandus regenerative arc-lamp.* This lamp is provided with what may be termed two chimneys, in which the principal deposit takes place; these chimneys, made of metal and enamelled white on the outside, are disposed on either side of the lamp with the object of obstructing as little of the light as is possible.

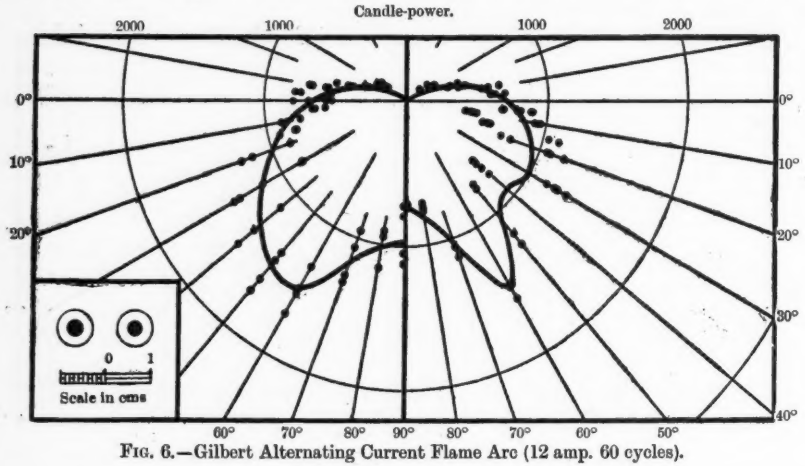


FIG. 6.—Gilbert Alternating Current Flame Arc (12 amp. 60 cycles).

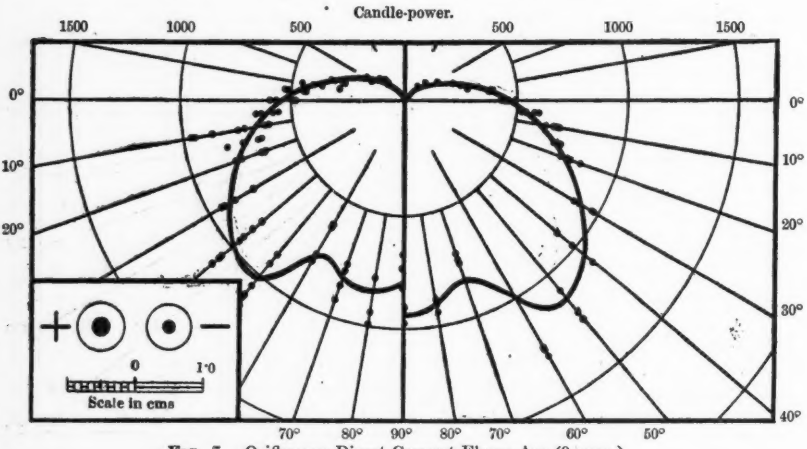


FIG. 7.—Oriflamme Direct Current Flame Arc (9 amp.).

This lamp being of such recent development, the author thought it desirable to test, besides its polar distribution of light and luminous efficiency, the volt ampere characteristics of the arc itself. In Fig. 10 are given the results of two tests for the polar distribution of light. A glance at these diagrams shows how considerable are the fluctuations in candle-power which have occurred during the tests. This is not so much due to a flicker as to a slower change in the light. Beside this change in candle-power a still slower change also

* See an article on this lamp by Mr. A. Denman Jones, *Illuminating Engineer*, April, 1908, pp. 310-312.

takes place in the colour of the light. No doubt these fluctuations will be minimized when the lamp has been further developed. Sections of the carbons are shown at the side of the diagram. It will be noted that the positive carbon, which is the lower, has a shape very similar to that employed in some of the early lighthouse carbons—the intervening spaces are, however, filled up with the special chemicals used to increase the luminous efficiency. In Fig. 11 are collected the approximate results of the volt ampere characteristics for this arc when controlled by hand instead of by the mechanism. The cross on one of the

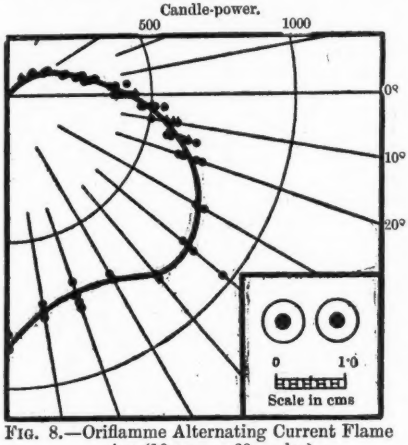


FIG. 8.—Oriflamme Alternating Current Flame Arc (10 amp. 60 cycles).

curves indicates the point for normal working conditions (volts 70, amperes 5·4, length 1·5 inches). No observations are shown on these curves, as the arc was rather erratic, although between one and two hundred measurements were made: the curves represent the mean of these observations. The figures on them give the apparent length of the arc in inches.

With the object of showing the diminished voltage drop between carbons and the arc, the curves in Fig. 12 have been plotted. Here are collected the observations connecting length of arc with volts on terminals of the arc for two constant currents, 2 amperes, and 5 amperes. Both of these curves indicate that a voltage as low as 20 is all that would be required for an arc of no apparent length, which, of course, is much lower than that obtaining for an ordinary open arc.

SPECTRA OF ARCS.—A number of observations have kindly been made for the author by Mr. A. G. Warren, B.Sc., on the spectra of the various arcs, during the course of these experiments. An ordinary table spectroscope was used, fitted with a scale, and the instrument had the usual 60 degrees prism. The results obtained, drawn to scale, are collected in Fig. 13. It will there be seen on inspection that the whiter light obtained with the Crompton-Blondel lamp when compared with the light emitted by the ordinary yellow flame carbons is due to the almost complete absence of a strong yellowish-green band, and to the accentuation of the blue and violet lines in its spectrum. For the purposes of comparison a few additional spectra were measured, such as the familiar sodium D lines, the spectrum of a hydrogen tube, and that of the Cooper-Hewitt mercury vapour lamp. As calcium salts are so largely used in the impregnation of flame carbons, it was thought desirable to obtain the spectrum of a salt of calcium through the intermediary of first a Bunsen flame, and, second, an electric arc. Calcium carbonate in the form of a fine precipitate was used as the salt. The method of obtaining the spectrum in the electric arc was to drill the core out of an ordinary cored carbon, and pack it with the calcium carbonate powder, using this as the positive carbon which formed the lower electrode of a hand-feed electric arc.

COLLECTION OF RESULTS OBTAINED.—In comparing the efficiencies obtained with the various arc lamps in these tests, due weight must be given to the fact that the quality of the carbons supplied with the lamps by the different manufacturers was very varied. It is well known that some of these lamps are capable of burning well, though consuming a cheap quality of carbon, whilst others require for proper performance a more expensive quality. With the object of being able to draw correct conclusions from these tests

Table II. has been drawn up, giving particulars of the carbons as far as is possible.

In Table III. are collected the available data of the lamps (with the exception of the carbons, particulars of which are given above) and the results of the tests. The lamps are grouped as before, viz., (1) open type, (2) enclosed, (3) [*a*] open flame D.C., [*b*] open flame A.C., and (4) enclosed flame. The facts given are date of test and maximum candle-power, this being read off from the curve drawn in the polar diagram, and giving a mean maximum rather than an actual instantaneous maximum. The next column contains the angle below the horizontal at which the maximum candle-power occurs. Then follows the mean spherical candle-power (M.S.C.P.) and the mean hemispherical candle-power (M.H.C.P.), obtained by means of the Rousseau diagram. Next the mean volts and amperes and the mean watts. It should be mentioned that the alternating watts given are really the apparent watts, and as the power factor of the

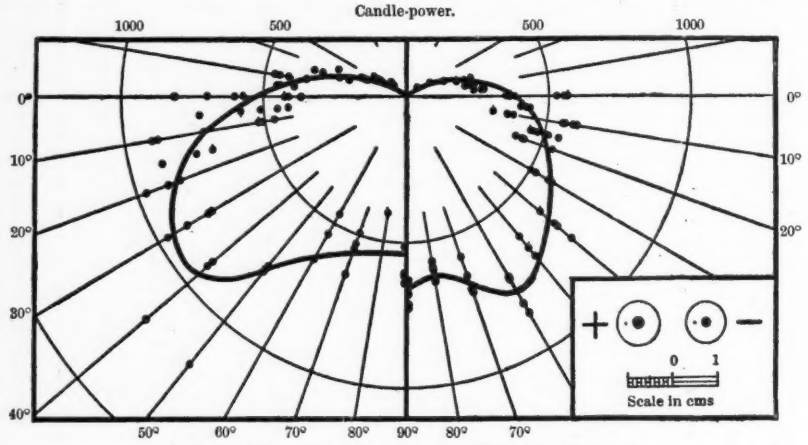


FIG. 9. Alternating Direct Current Flame Arc (9 amp.).

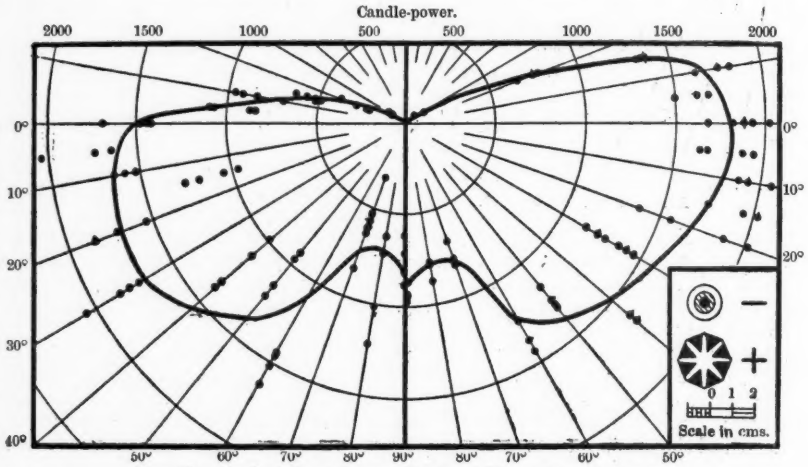


FIG. 10.—Jandus Direct Current Enclosed Flame Arc ($5\frac{1}{2}$ amp.).

TABLE II.

Name of Lamp.	Style of Carbons.	Remarks.	Diameter in Millimetres.	
			External.	Core.
Excello D.C.	"Krone-Excello" 104 ♔ C. Conradty " " 105 " "	Wire embedded in carbon throughout its entire length.	10 9	4 positive. 2·5 negative.
Gilbert D.C.	"Noris-Excello" 104 * * * C. Conradty "Noris-Excello" 104 * * * D. R. Patent 150956 * * * C. Conradty	Wire embedded in carbon throughout its entire length	9 8	4·5 positive. 4 negative.
Gilbert A.C.	* A F — Ship-Carbons  Vienna-Austria	Copperplated	8	3
Oriflamme D.C.	— A F — Ship-Carbons ΔΔΔ Vienna-Austria		7 6·4	2·3 positive. 1·8 negative.
Oriflamme A.C.	Ship Carbons Vienna Austria Q F		6·25	2·0
Westinghouse D.C.	Excello Noris Conradty {104 105		10 9	2·5 positive. 2 negative.
Jandus Enclosed Flame D.C.	Special star-shaped Carbon for Positive —L—A—Dochtkohle C—Niederspannung, Gebr. Siemens & Co., Charlottenberg		 15	positive. 9 and 5 negative.
Crompton Blondel D.C.	////// Cont 51 ////// + S. F. Auer + /// Brevete S G D C - - - - - Charbons Mainbottel — C C - - - -		14 9	14 positive. 2 negative.
New Century D.C.	—— C. Conradty Nuernberg — Marke C ——		18 13	5 0
Jandus Enclosed D.C.	— — — — Eos — — — — — — — — Jandus — — — — —		13 13	0 positive. 0 negative.

TABLE III.

Name of Lamp.	Date.	Max. C.P.	Angle of Max.	M.S.C.P.	M.H.C.P.	Mean V. A.	Mean Watts.	M.S.C.P. per Watt.	M.H.C.P. per Watt.	Light emitted.	Corrected M.S.C.P. per Watt.
			Degrees.							Per Cent.	
New Century D.C. open 15 amp.	9/6/08	930	43	600	810	51 × 15	765	0·78	1·06	75	1·0
	6/7/08	1,100	50	570	790	54 × 15	810	0·71 } 0·75	0·98 } 1·0		
Jandus Enclosed Ordinary 5 amp.	25/5/08	570	42	250	340	80 × 5·8	465	0·54	0·73	91	0·6
	27/5/08	560	39	230	350	80 × 5·7	455	0·55 } 0·55	0·77 } 0·75		
Crompton-Blondel 10 amp.	29/5/08	1,080	10	720	910	40 × 10	400	1·80	2·27	60	3·25
	10/7/08	1,380	14	845	1,110	40 × 10	400	2·11 } 1·95	2·77 } 2·5		
Excello 10 amp.	1/6/08	1,720	60	900	1,400	47 × 10	470	1·92	2·98	74	3·05
	6/7/08	2,550	70	1,130	1,830	44 × 10	440	2·57 } 2·25	4·16 } 3·55		
Gilbert D.C. 10 amp.	16/6/08	2,450	60	1,240	2,000	48 × 10	480	2·58	4·17	78	2·9
	10/7/08	2,140	61	915	1,490	47 × 10	470	1·95 } 2·25	3·17 } 3·65		
Oriflamme D.C. 9 amp.	12/6/08	1,020	47	495	825	38 × 10?	380	1·30	2·17	67	2·3
	6/7/08	1,140	52	540	880	34 × 9	305	1·77 } 1·55	2·89 } 2·55		
Westinghouse 9 amp.	13/6/08	960	36	550	790	54 × 9	485	1·13	1·63	58	1·55
	10/7/08	750	59	340	585	55 × 9	495	0·69 } 0·9	1·18 } 1·4		
Gilbert A.C. 12 amp.	19/6/08	1,520	56	695	1,130	55 × 11·5	630	1·10	1·79	73	1·45
	15/7/08	1,500	60	640	1,000	55 × 11·8	650	0·98 } 1·05	1·54 } 1·65		
Oriflamme A.C.	13/7/08	820	45	430	690	44·2 × 10	440	0·98 } 1·0	1·57 } 1·55	65	1·55
		880	90								
Jandus Enclosed Flame 5½ amp.	24/6/08	1,700	15—30	885	1,425	58 × 6·1	355	2·49	4·01	84	3·15
	26/6/08	1,820	0—10	1,045	1,400	59 × 6·3	370	2·82 } 2·65	3·78 } 3·9		

arc-lamp may be ·95 or even ·90, this may cause these alternating lamps to appear some 5 per cent or 10 per cent low in their performance. The next two columns give the M.S.C.P. per watt and the M.H.C.P. per watt, and in the same column are contained the mean figures for the results of the two tests on each lamp. In the last column but one appear figures deduced from Table I. expressing the percentage of light passed by the globe or other exterior enclosure. It should be remarked that in the case of the enclosed lamps the absorption produced by the inner enclosure has not been allowed for, as it is impossible for these lamps to operate with less than one enclosure. The last column gives the M.S.C.P. per watt, increased by the amount of light cut off by the globe (corrected M.S.C.P. per watt). The angle at which the maximum candle-power occurs will be found to have a very wide range, viz., from 0 degrees to 90 degrees.

	M.S.C.P. per Watt.
High Grade Flame Carbons	2·9 to 3·3
Lower Grade „ „	1·5 to 2·5
Ordinary Carbons Open	About 1
„ „ Enclosed	About 0·6

DEGREE OF ACCURACY. — Although great vigilance has been exercised in the working out of the observations, it is to be feared that some small errors may have crept in, as over 2,000 distinct measurements, to take candle-power alone, have been made for these tests. The author, however, is of the opinion that the degree of accuracy obtained by the means of the two tests is well within 10 per cent, with one possible exception. Taking the lamps as a whole, the enclosed flame takes the first position as far as efficiency is concerned, yielding 2⅝ M.S.C.P. per watt; next come those lamps using the higher grade Excello carbons (2¼ M.S.C.P.); these are closely followed by the lamp using the Auer carbons (about 2 M.S.C.P.). When, however, an attempt is made to eliminate the diminution of light due to the absorption of the globe, the Auer carbons, the enclosed flame, and the high-grade Excello carbons, all give results ranging from 3 to 3¼ M.S.C.P. per watt. In fact, a brief summary of the present position as regards *true efficiency* is as follows :—

Whilst, considering the efficiency in a more commercial way, the results being based on the mean *hemi*spherical candle-power, and referring to the *complete* lamps as supplied by the manufacturers are :—

	M.H.C.P. per Watt.
Lamp with High Grade Flame Carbons Enclosed	3·9
Ditto Open	3·5—3·7
Lamp with Auer Carbons	2·5
Lamp with Lower Grade Flame Carbons	1·4—2·5
Lamp with Ordinary Carbons Open	About 1
Ditto Ditto Enclosed	About 0·75

GENERAL REMARKS.—An examination of the polar diagrams obtained for all the arcs tested, as also for the gas lamps referred to in the previous article, reveals a very great diversity in the forms of the light distribution curves. These variations are due, first, to the different disposition of the carbons; second, to the form of reflector employed, internal and external; and third, to the opacity of the globe.

The author has lately had the advantage of discussing this matter of correct distribution of light for the particular case of public street lighting with quit

a number of arc-lamp manufacturers and other engineers, and finds that widely divergent opinions are held upon this subject. On the whole it seems to him that the following are

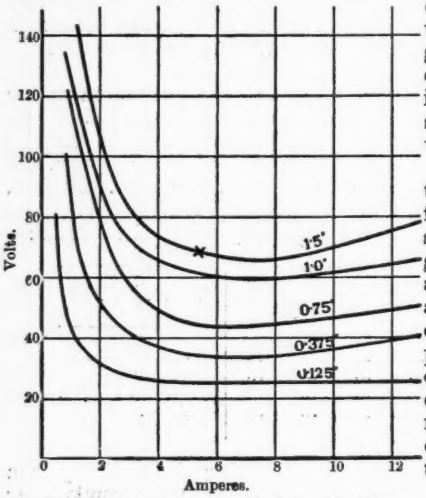


FIG. 11.—Volt-ampere characteristic for various arc-lengths for Jandus enclosed flame arc.

some of the more important points: (*a*) Distribution of light from naked arc, including any internal reflectors; (*b*) absorption of globe and its effect in redistributing the light; (*c*) use of an external reflector and its permissible size; and (*d*) height of centre of arc from ground.

The author considers that, for the purposes of street lighting, practically no light should escape above an angle of some 15 degrees to 20 degrees below the horizontal, and, further, it is obvious that the candle-power in directions vertically downward should be considerably below that sent out in sloping directions. The objects to be attained are: (1) a uniform vertical illumination on the ground; and (2) the screening of the light from the horizontal line of sight of the observer. The first of these objects appears to be fairly appreciated, but the second is very far from receiving the attention it deserves; in fact, to the author it appears that many members of electric lighting committees and a large section of the general public would not consider a street properly lighted if the sources of light were not at once conspicuous to the eye. He is fully alive to the fact that to prevent the eye being dazzled by the source of light, the use of almost unmanageably large reflectors would be necessary with the sizes of globe at present in vogue; but more ordinary-sized reflectors could be used, if the lamps could be provided with smaller globes, particularly enclosures whose vertical dimension is small.

Much more attention should be given to the production of suitable globes for intense lights. The foregoing tests show absorptions for partly obscured globes ranging between 15 per cent and 45 per cent, whilst Dr. Marchant, as referred to above, mentions amongst others a case of as much as even 90 per cent loss. This is a matter requiring careful testing, as appearances are decidedly misleading, and a globe which reduces the candle-power considerably does not necessarily greatly diminish the staring effect of the light.

The author is convinced that it would well repay many arc lamp manufacturers, and also extensive users

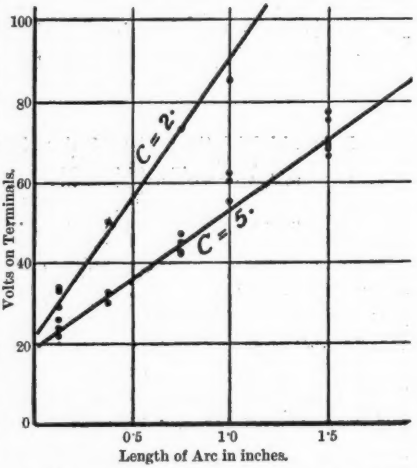


FIG. 12. Volt-length characteristics for various constant currents for a hand-feed Jandus enclosed Flame Arc.

of arc lamps to wholly reconsider the methods of screening and reflecting now in use.

The author desires, in conclusion,

to express his thanks to many students of the Electrical Engineering Department of the East London College who have assisted him in several ways during the preparation of material for this article. Specially would he mention Mr. J. F. Forrest for the enthusiastic assistance which he has rendered throughout the whole of the photometric tests; his thanks are also due to Mr. E. J. Surman. To Messrs. A. G. Warren, B.Sc., and F. Stroude, B.Sc., he is also much indebted for their kind help in working out these tests.

FIG. 13.—Spectra of various Arc Lamps.

The Running Cost of Acetylene Lighting.

By A French Correspondent.

Acetylene is always obtainable in practically the same degree of purity from carbide of calcium, and should invariably yield the same illuminating power when utilized in exactly the same way. A given volume of acetylene, burnt under given conditions, should therefore always give us the same light, although it may be difficult to say beforehand the intensity of light that will be derived from a given volume of ordinary illuminating gas, as the composition of the mixture is very variable.

On the other hand, it may be urged that the ordinary user of acetylene does not actually purchase this gas. From his point of view, acetylene is merely an intermediary between the carbide and the actual light obtained, and he is mainly concerned with the quantity of light to be obtained from a given amount of calcium carbide.

This, of course, is perfectly true. The cost of acetylene lighting depends on two factors—the price of calcium carbide and the return that may be secured by making use of it. However, it may be accepted that in the case of a satisfactory installation a cubic metre of acetylene will be obtained at a cost of 1·16 francs, or, in round numbers, 1·20 fr., assuming the cost of carbide to be 35fr. per 100 kilos. On this figure we shall base such results as are given in the present article.

In the first place it may be remarked that here, as in the case of coal-gas, we must distinguish between :—

1. Lighting by means of an open illuminating flame.
2. Lighting by incandescence.

As regards the first of these methods it may be stated that acetylene, being the hydrocarbon richest in carbon, is, in virtue of this richness, in the position to yield a particularly luminous flame. The illuminating value of a flame depends upon the presence of a large number of solid particles of carbon, carried to incandescence by the heat of combustion and the temperature to which these particles are subjected. Now the acetylene flame possesses a high temperature and, being so rich in carbon, is also particularly adapted to the formation of a large number of particles of this nature.

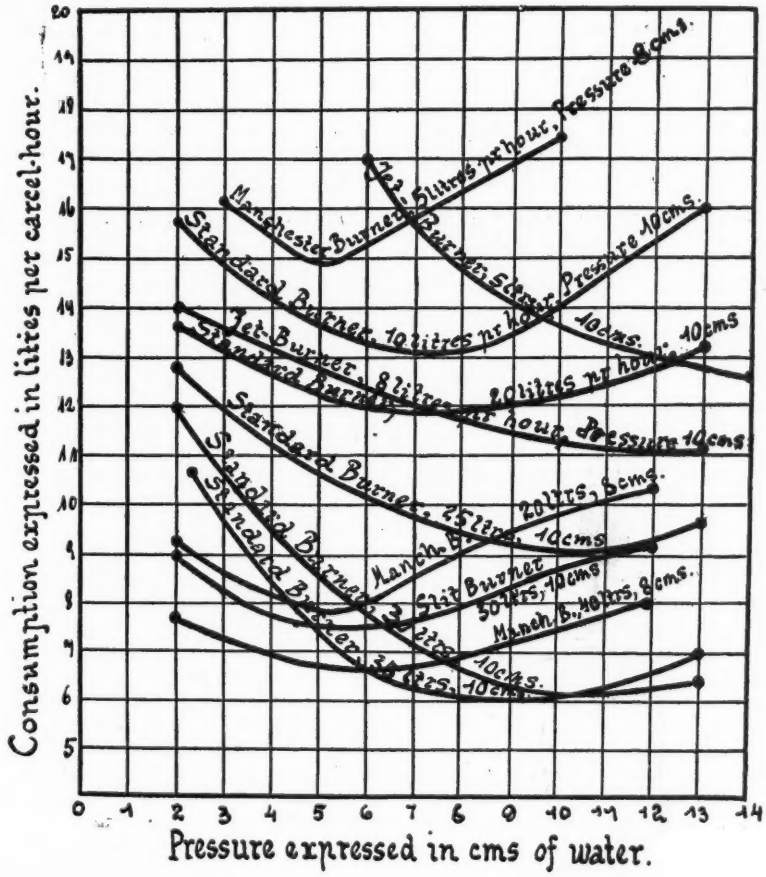
The actual illuminating value of acetylene, however, depends upon the variety of burner utilized. In general burners consuming a large amount of gas are more efficient than those consuming comparatively little. For example, the "Conjugué" standard series of burners, consuming 10, 20, 25, 30, and 35 litres respectively, give the following results :—

The 10 litre burner consumes			13·1	litres	per carcel-hour.
„ 20	„	„	11·8	„	„
„ 25	„	„	9·2	„	„
„ 30	„	„	6·2	„	„
„ 35	„	„	6·1	„	„

These results were obtained by using the most suitable pressures, namely 7 centimeters in the case of the first two burners and 10 in the case of the others. Assuming, therefore, our previously stated price of 1·20 fr. per cubic metre of acetylene, we see that the price of a carcel-hour varies from about 1·57 centimes in the case of the first burner, consuming 10 litres per hour, to 0·73 in the case of the burner consuming 35 litres.

The pressure under which acetylene is burnt at the burner is of considerable importance. As a rule, in the case of a certain burner, there exists one definite pressure more favourable than any other. Thus in the figure we see the illuminating powers of various types of burner expressed as a function of the pressure, as recently communicated by M. Granjon at the International Congress on Acetylene and Calcium Carbide.

It may be interesting to compare the cost of acetylene lighting by illuminating flames with that of coal-gas on the same methods. A flat-flame "butterfly" gas burner consumes about 100 litres per carcel-hour, and therefore costs about 1·5 centimes per carcel-hour, assuming the cost of gas to



be 15 centimes per cubic metre. On the basis of the cost of the more old-fashioned method of gas lighting, therefore, acetylene lighting would work out the cheaper of the two. This result is now only of interest retrospectively, but it shows that the contention of the earlier workers in the domain of acetylene lighting, that their system would displace gas for street lighting, was not without justification at that time, when the incandescent mantle had not been developed, or had led to but meagre results.

To-day the discovery of the incandescent mantle has revolutionized gas lighting. But it may also be said that the application of incandescent mantles to acetylene lighting has achieved great results.

The writer proposes to deal with this aspect of the subject in greater detail in a subsequent article. It may, however, be said in the meantime that the use of incandescent mantles with acetylene has reduced the cost of lighting

by about 60 per cent, and that the running cost of lighting by this means now amounts on the average to about 0·40 centimetres only.

There is, of course, also the cost of the mantles to be borne in mind, but this is extremely small provided mantles of the right kind are utilized.

The writer is actually using mantles which have burnt for ten hours daily for three months without being changed or undergoing any noticeable deterioration. This longevity is partially due to the smallness of the mantles, but there are probably other contributory causes. There are those who consider the introduction of mantles a complication, but in reality it is much simpler to change the mantle at the end of 900 hours than to clean out, after only 100 hours' burning, choked-up burners of the ordinary variety.

A Recent Method of Increasing the Efficiency of Incandescent Gas-Burners.

A RECENT number of *The Journal of Gaslighting* contains a description of an ingenious method of increasing lighting efficiency. The method consists in fitting



FIG. 1.

a solid conical body made of refractory material over the ordinary supporting prop for the mantle as shown in the illustration.

One object of this device is to control the volume of flame coming in contact with the mantle, and to direct this flame on to it, so that the entire surface of the mantle becomes incandescent. In addition to this the presence of the heated solid body in the centre of the flame has the effect of increasing the flame temperature. As a result, it is claimed that an increase in illuminating power of 20 per cent is secured, and on one series of tests it was found that a No. 4 Kern burner yielded 58 candles without the core, and an average of 81 candles with it, for a consumption of 4·2 cubic feet.

It is also suggested that the life of a mantle is improved, and for two reasons: in the first place the introduction of the solid core tends to stiffen the flame and to steady the mantle. Many mantles of the upright variety are broken by their tendency to sway to and fro when lighted up. In the second place, it seems likely that the life of a burner is affected by the severe changes of temperature occasioned by lighting up and extinguishing; and the presence of a heated solid body having considerable heat-capacity affords the mantle the protection of a slower method of cooling. It is stated, for instance, that in one breezy road in Brighton the average mantle-renewal for three months has been reduced to 1·6 per lamp as opposed to 3·8 without the core.

The system is also applicable to inverted mantles, a pear-shaped core, having its apex in the burner-nozzle, being used. At present, however, owing to the irregular shapes often assumed by burners of this class during use, the results have not been so successful.

Tests on Electric Incandescent Lamps.

By Prof. H. Bohle,
South African College, Cape Town.

In the present article a number of simple tests on electric lamps have been analyzed with interesting results. The lamps tested were the following :—

(1) Carbon filament lamps.
(2) Nernst lamps.
(3) Tantalum lamps.
(4) Osram lamps.

The results of the experiments were represented by plotting the candle powers against (1) the volts, (2) the amperes, (3) the watts, (4) the watts per candle power, and (5) the current against the resistance in ohms. The equations to the different curves are as follows :—

Carbon lamp.	Nernst lamp.
$T=5{\cdot}08\times10^{-16}\,V^{7}$	$T=0{\cdot}28\times10^{-20}\,V^{9\cdot35}$
$=16{,}000\,I^{5\cdot5}$	$=536\,I^{2\cdot6}$
$=0{\cdot}392\times10^{-4}\,P^{3\cdot1}$	$=3\times10^{-3}\,P^{2\cdot15}$
$=124\,\eta^{-1\cdot476}$	$=160\,\eta^{-1\cdot87}$
$R=610\,I^{-0\cdot214}$	$=310\,I^{-\cdot72}$

Tantalum lamp.	Osram lamp.
$T=0{\cdot}11\times10^{-7}\,V^{4\cdot4}$	$T=0{\cdot}16\times10^{-6}\,V^{4\cdot0}$
$=16{,}400\,I^{6\cdot0}$	$=16{,}000\,I^{6\cdot0}$
$=6{\cdot}4\times10^{-3}\,P^{2\cdot15}$	$=5{\cdot}8\times10^{-3}\,P^{2\cdot3}$
$=80{\cdot}7\,\eta^{-1\cdot87}$	$=52\,\eta^{-1\cdot77}$
$R=580\,I^{0\cdot36}$	$R=562\,I^{0\cdot5}$

in which

T=luminous intensity in pentane candles.
V=volts at terminals of lamp.
I=current in amperes.
P=watts absorbed by lamp.
η=economy or watts per candle.
R=resistance in ohms.

In each case new and old lamps were tested, but it was found that the exponents in the various equations were practically constant for the same type of lamp, and that only the coefficients varied. Carbon lamps from different makers possess, however, different exponents. Thus the voltage exponent for a Stearn lamp was 6·5, for an Ediswan lamp 7·2. One Nernst lamp was apparently a freak, the voltage exponent being as high as 14!

The results given here are of considerable importance, not only to the manufacturer of electric lamps, but also to the consumer. We see that the Nernst lamp is mostly affected by variations in the supply P.D., the Osram lamp least. From the curves $f(T,\eta)$ it would appear that the Tantalum and Nernst lamps were capable of being made more economical than carbon and Osram lamps, because the negative exponent is 1·87 against 1·476 of the carbon and 1·77 of the Osram lamp. Because these exponents will depend chiefly upon the material of the filaments, whereas the coefficients relate more to the process of manufacture, the age of the lamp, the state of the bulb, &c. That the ultimate Tantalum lamp will be vastly more economical than the present one I have not the slightest doubt. The tests on the latest type show already the following improved results :—

Lamp 1. C.-p.=18·96, Economy=1·46.
,, 2. ,, =16·62, ,, =1·65.

At present the economy of the Osram lamp is superior to that of the Tantalum lamp, this being possibly due to easier methods for economic manufacture and greater competition.

Of great importance are the curves $f(T, V)$. To make the variation of candle-power small as the supply P.D. varies, the manufacturer should aim at producing filaments with positive temperature co-efficients, as in the Tantalum and Osram lamps, so that the resistance increases with the current instead of being lowered as the temperature goes up, as occurs in carbon filament and Nernst lamps

To see how much the light of various lamps varies on a central station supply, a record was taken of the

voltage of one side of a three-wire network between 4.30 and 9.30 P.M. From this record the curve has been reproduced on a larger scale, as is shown in Fig. 1, the readings having been plotted in intervals of five minutes. It will be noticed that the total variation is from 212 to 230 volts, the normal P.D. being 220. A variation of 18 volts in 220, or 8 per cent, must be called excessive. The variation may be due to a non-uniform supply at the bus bars or to drop in the mains.

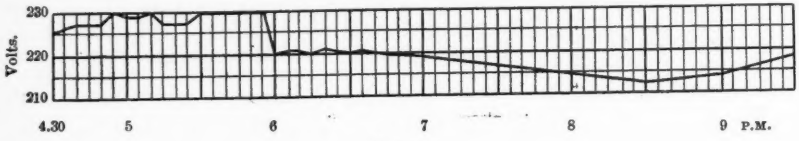


FIG. 1.

The variation in candle-powers for the various types of lamps has been plotted in Fig. 2, and the percentage variation in Fig. 3. We see from these figures the enormous advantages which the metal filament lamps held over the carbon and Nernst lamps. The irregularity of the Nernst lamp would have been even worse if it were not for the iron resistance in the lamp, the resistivity of which increases enormously as the current rises above the normal. In spite of this the candle power rises 36 per cent above and drops 34 per cent below the normal, all within the time of five hours.

That such a variation cannot but be harmful to the eyes of people who have to work under these conditions goes without saying.

F. Hirschauer, Munich,* has expressed the percentage total variation of candle-power by $2px_v$, in which p is the variation of the supply P.D. above or below the normal. This is proved as follows. The candle-power of any lamp may be expressed by

$$T = K_v V^{x_v}$$

In this equation X_v is constant for the same type of lamp, for instance $X_v = 4{\cdot}0$ for the Osram lamp. K_v is a coefficient constant for the same lamp, but dependent upon the age of the lamp and the maker. Suppose now the voltage V is increased or decreased by p per cent, then

$$T_1 = K_v\left(V + V\frac{p}{100}\right)^{x_v} = K_v\left\{\left(1 + \frac{p}{100}\right)V\right\}^{x_v}$$

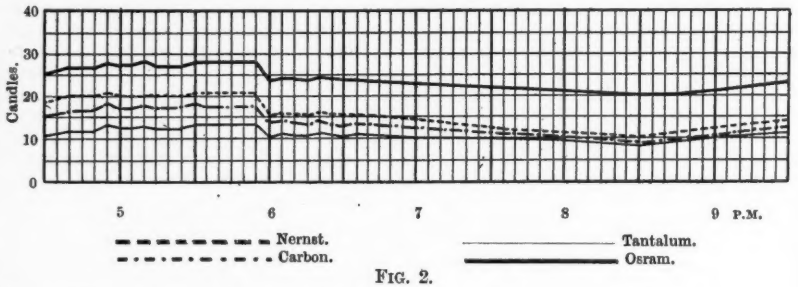


FIG. 2.

$$T_2 = K_v\left(V - V\frac{p}{100}\right)^{x_v} = K_v\left\{\left(1 - \frac{p}{100}\right)V\right\}^{x_v}$$

The total variation in the candle-power is then

* *Elektrotechnische Zeitschrift*, 1908, p. 87.

$$T_1 - T_2 = K_v V^{x_v}\left\{\left(1+\frac{p}{100}\right)^{x_v} - \left(1-\frac{p}{100}\right)^{x_v}\right\}$$

But according to the binominal theorem

$$\left(1+\frac{p}{100}\right)^{x_v} = 1 + {}^{x_v}{}_1\frac{p}{100} + \frac{x_v}{\lfloor 2}\left(\frac{p}{100}\right)^2 + \frac{x_v}{\lfloor 3}\left(\frac{p}{100}\right)^3 + \ldots$$

$$\left(1-\frac{p}{100}\right)^{x_v} = 1 - {}^{x_v}{}_1\frac{p}{100} + \frac{x_v}{\lfloor 2}\left(\frac{p}{100}\right)^2 - \frac{x_v}{\lfloor 3}\left(\frac{p}{100}\right)^3 + \ldots$$

and

$$\left(1+\frac{p}{100}\right)^{x_v} - \left(1-\frac{p}{100}\right)^{x_v} = 2\,{}^{x_v}{}_1\frac{p}{100} + 2\frac{x_v}{\lfloor 3}\left(\frac{p}{100}\right)^3 + \ldots$$

This series converges very rapidly, so that even the second member may be neglected, since for $X_v=14$ the result is affected by less than 1 per cent. We obtain, therefore,

$$T_1 - T_2 = K_v V^{x_v} 2\, x_v \frac{p}{100},$$

and the percentage candle-power variation

$$\frac{T_1 - T_2}{T} \times 100 = \frac{K_v V^{x_v}\, 2\, x_v \frac{p}{100}}{K_v V^{x_v}} \times 100 = 2\, x_v\, p.$$

By plotting this variation in the candle-power as function of 2p, we obtain Fig. 4.

Suppose now the percentage variation in the candle power is given, then we find the corresponding allowable percentage pressure variation by drawing a horizontal line through the given percentage candle-power variation, which cuts the lines for the various lamps in the desired points. Assume, for instance, the light variation is not

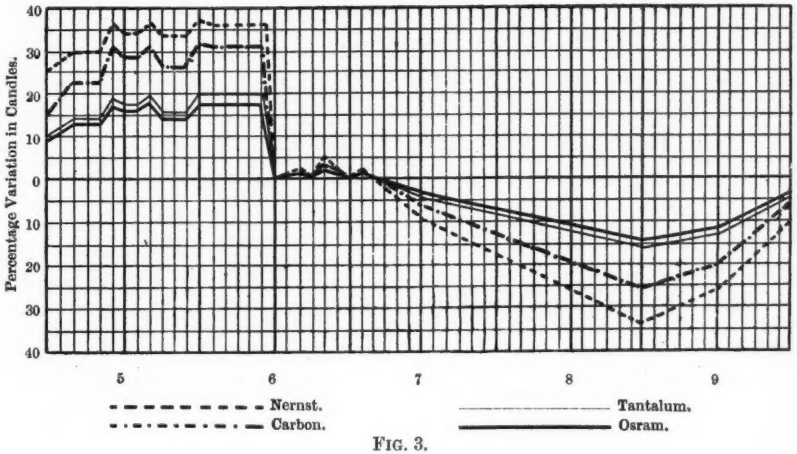


FIG. 3.

to exceed 15 per cent, then the percentages of the allowable pressure variations to either side are

Carbon lamp	1·07	or total	2·14
Nernst lamp	0·8	,, ,,	1·6
Tantalum lamp	1·7	,, ,,	3·4
Osram lamp	1·87	,, ,,	3·74

In the case of a 220 volt supply the pressure at the terminals of the lamp would have to be regulated to within—

Carbon lamp	217·65 to 222·35 volts.
Nernst lamp	218·24 to 221·76 ,,
Tantalum lamp	216·26 to 223·74 ,,
Osram lamp	215·89 to 224·11 ,,

With these figures it is easy to calculate the cross sections of feeders. Take the following example :—

A large building requires light to the extent of 16,000 candle-powers, and the variation in the light is not to exceed 15 per cent in all. Let us assume that the supply pressure at the central station bus bars is constant,

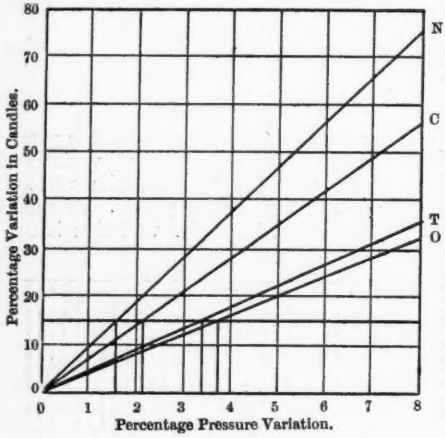


FIG. 4.

that the economies of the different types of lamps are

Carbon lamp $\eta = 3{\cdot}5$ watts per candle
Nernst lamp $\eta = 2{\cdot}0$,, ,, ,,
Tantalum lamp $\eta = 1{\cdot}5$,, ,, ,,
Osram lamp $\eta = 1{\cdot}3$,, ,, ,,

and that the distance from the station to the building is 1 kilometre. The drop in the mains is given by the above allowable total pressure variation. We have

Carbon lamp, drop $= \frac{2{\cdot}14}{100} \times 220 = 4{\cdot}7$ volts

Nernst ,, ,, $= \frac{1{\cdot}6}{100} \times 220 = 3{\cdot}52$,,

Tantalum ,, ,, $= \frac{3{\cdot}4}{100} \times 220 = 7{\cdot}48$,,

Osram ,, ,, $= \frac{3{\cdot}74}{100} \times 220 = 8{\cdot}23$,,

The currents carried by the mains in the various cases are :—

Carbon lamp, 255 amperes.
Nernst lamp, 146 ,,
Tantalum lamp, 109 ,,
Osram lamp, 95 ,,

The resistances of the mains are :—
Carbon lamp 0·0184 ohm.
Nernst lamp 0·0241 ,,
Tantalum lamp 0·0687 ,,
Osram lamp 0·0866 ,,

The cross sections of the mains follow from :—

$$S = P \times \frac{1}{R} = 0{\cdot}017\frac{2000}{R}$$

Carbon lamp 1,848 mms.^{2} (100 per cent)
Nernst lamp 1,410 ,, (75·7 ,,)
Tantalam lamp 495 ,, (26·8 ,,)
Osram lamp 392 ,, (21·2 ,,)

These cross sections are excessively large, due to the fact that we have assumed constant station P.D., whereas it is more economical for constant light to lay out a station plant and network for constant P.D. at the feeding points. With constant P.D. at the feeding points, the following cross sections would have been sufficient :—

Carbon lamp 170 mms.^{2}
Nernst lamp 97 ,,
Tantalum lamp 73 ,,
Osram lamp 64 ,,

Whatever the arrangement of plant and network be, we may summarize our results as follows :—

(1) The new metal filament lamps are vastly superior to the carbon lamp as regards economy and uniformity of light on an irregular supply, and also superior to the Nernst lamp as regards the latter.

(2) For a given variation in the candle-power of lamps, the regulation of the supply P.D. must be much closer for Nernst and carbon lamps than for Tantalum and Osram lamps.

(3) If no provision is made for raising the P.D. at the bus bars at the station so as to keep the P.D. at the feeding points constant, the calculation of the feeders for carbon and Nernst lamps must be far more liberal than for Tantalum and Osram lamps, if the variation of the light is to be kept within reasonable limits.

In conclusion I have to thank Messrs. Jack and Pickard, students in my department, for carrying out part of the experimental work connected with this paper.

A New Method of Illuminating the Exteriors of Buildings.

AN article in our special section in the August number of *The Illuminating Engineer* dealt with the illumination of the exteriors of buildings with a view to bringing out their architectural features by night. It was suggested that the most natural method of achieving this effect was by illuminating the building as a whole from without rather than by attempting to reproduce its main outlines in incandescent lamps.

We notice in a recent number of *The Electrical World* an account of the lighting of the Singer Building Tower in New York, in which this method has been aimed at for the purpose of spectacular effect. The highest point on the roof of this tower is 612 feet above the pavement, and it contains forty stories above the level of the street, and covers a ground area of 24,000 sq. feet. It is therefore a striking object, visible from a considerable distance, and specially suitable to the method of illumination adopted.

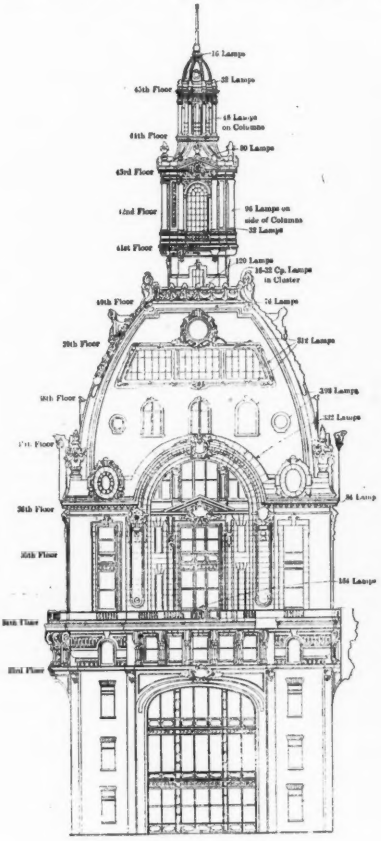


FIG. 1.

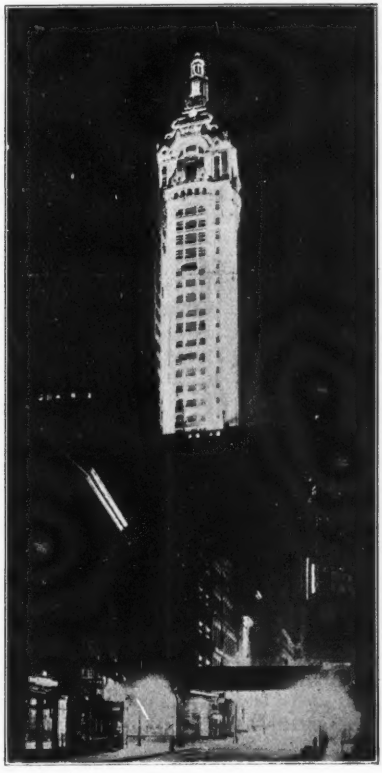


FIG. 2.

The illumination of the outside of the building is obtained mainly by the use of incandescent lamps. Instead of being employed for "outline-lighting," however, these lamps are concealed behind the cornices and balconies surrounding the building, and are equipped with reflectors concentrating their light upon its exterior. The general method of arranging these lamps will be understood from Fig. 1; there are said to be 1,600 lamps in all used to illuminate the section of the tower above the thirty-fourth floor. On the top of the dome is an ornamental lantern 16 feet square at the base and 60 feet high, and above this again a small flagpole reaching, eventually, a height of 652 feet.

In addition to the local lighting by incandescent lamps, intended to bring out special features of the exterior of the building, searchlights are made to illuminate the building as a whole, and to wash with light wide tracts of area that could not easily be effectually treated otherwise. Over twenty-five of these special searchlights are located on the roofs of the buildings at the base of the tower, shutters being provided to restrict the light to the space occupied by the tower and cause it to stand out against a dark background. It is also proposed to keep a searchlight beam playing upon the flag at the summit of the tower.

As will readily be understood from the illustration in Fig. 2, the tower forms a striking object by night, and is visible a considerable distance away. It is stated, moreover, that this illustration hardly conveys the pleasing character of the effect, as the tower here seems to present a somewhat ghostly and spectral appearance. Actually the warm tones of the brick and the tint of the copper dome at the summit of the building preserve it from giving this impression.

The possibilities of this method of lighting from a purely spectacular and advertising point of view are interesting. There seems, however, also ample room for the ingenuity of the architect in applying the system to buildings of exceptional architectural and historic interest. For, having artificial light at his command, he is in a position to secure that the light comes from the correct direction, producing the desired play of light and shadow, and throwing into prominence and relief just those portions of the building that justify this treatment.

Some Instances of the Need for the Illuminating Engineer.

REFERENCE has recently been made in our columns to the cases that are constantly arising in which the need for a reliable impartial authority is made evident. We notice a number of instances, referred to in the current technical press, in which the method of illuminating some public building is discussed and the decision of the authorities questioned.

It need only be repeated that in such cases it is essential that the matter should be placed in the hands of a competent expert in illumination. At present there is a growing tendency to consult an outside adviser in such circumstances. It is becoming more and more generally realized that important issues are involved. But the decisions of such an expert can only give satisfaction when his acquaintance with different systems of lighting and impartiality are recognized.

At present, it must be admitted that in many cases an outside expert is consulted mainly on account of his repute in general engineering and quite irrespective of his knowledge of the subject of *illumination*. Under these circumstances it is hardly to be wondered at that his decision is often called in question and remains a source of dissatisfaction.

The Photometric Measurement of Illumination for Architectural Purposes.

By Percy J. Waldram, F.S.I.

The determination of the proper amount of illumination for interiors is a problem which architects are constantly being called upon to face. Whilst on the one hand insufficient window-space or meagre artificial illumination will at once condemn an otherwise good building in the eyes of the most easy critic, on the other hand over-large windows have to be avoided as giving a particularly cheerless, uncomfortable appearance in dull weather, making rooms cold and draughty in winter, and being liable to destroy the internal and external balance and harmony of a design. In the case also of buildings in large towns erected on highly expensive land and let necessarily at high rentals, the space to be devoted to light wells becomes a matter for the most serious consideration.

In the same way excessive artificial lighting has to be avoided, being almost as bad in its general effects as too little, and being even more trying to the eyes, as well as unduly expensive.

Important as these considerations are in the case of private houses, they impose an infinitely greater responsibility upon the architect designing schools, libraries, hospitals, &c., where mistakes in the predetermination of illumination, whether natural or artificial, are of so much greater moment. But whatever the building, every architect is aware of the enormous advantage to be obtained by well-proportioned windows and by artificial lighting, where the proper mean has been found between glare and gloom.

Yet although architects are constantly fixing the dimensions of windows and the extent and distribution of artificial lighting; although they are constantly rendering themselves responsible for the comfort and health of those who will occupy their buildings for generations—although, to put it at the lowest level, successful illumination means money to them whilst unsuccessful illumination means loss, it is not too much to say that they are guided in this important matter by guesswork only, or at the best by the application of approximate empirical rules which do not vary with varying conditions.

The London Building Act, 1894, Section 70(c), enacts that "Every habitable room shall have one or more windows....with a total superficies clear of the sash frames, free from any obstruction to the light equal to at least one-tenth of the floor area of the room....but a room having no external wall or a room constructed wholly or partially in the roof may be lighted through the roof by a dormer window with a total superficies clear of the sash frame equal to at least one twelfth of the floor area of the room ....or such room may be lighted by lantern light." The same regulations are contained in the Model Bye Laws of the Local Government Board and in nearly all by-laws founded upon them for urban districts.

It is by no means uncommon for the dimensions of proposed windows to be determined by considerations entirely unconnected with illumination so long as these minima are not infringed, although they are the same for windows in an enclosed area as for windows overlooking a park.

The aspect of a window, its shape, the solid angle subtended in the clear sky visible from it, the colour of the opposing walls, and the interior decoration all affect its illuminating power, but so completely has the science of illumination been ignored hitherto, that not one architect in a hundred, probably not one in a thousand, would

know how to calculate the additional window space required to afford equal illumination under adverse conditions.

Experienced architects, when fixing window dimensions, can depend upon the intuition derived from a series of previous approximations more or less successful; younger architects can only trust to guesswork and luck.

In the Building Regulations (1907) issued by the Board of Education for new schools under their control will be found the following regulations as to windows.

RULE 6—LIGHTING.

The area of window glass should approximate to one-fifth the area of the floor space in rooms used for teaching, and in other rooms to not less than one-eighth. Every part and corner of a school should be well lighted. The light in class-rooms must be admitted from the left side of the scholars. All other windows in class rooms should be regarded as supplementary or for ventilation. Where left light is impossible right light is next best. Windows full in the eyes of scholars cannot be approved. Unless the top of the windows be more than 12 ft. above the floor the plan should show no space more than 20 ft. from the window-wall in any room used for teaching.

(*a*) Windows should never be provided for the sake merely of external effect. All kinds of glazing which diminish the light and are troublesome to keep clean and in repair must be avoided. A large portion of each window should be made to open for ventilation and for cleaning.

(*b*) The sills of the main lighting windows should be placed not more than 4 ft. above the floor; tops of windows should, as a rule, reach nearly to the ceiling; ....

(*c*) Skylights are objectionable. They cannot be approved in school rooms or class rooms. They will only be allowed in central halls having ridge or apex ventilation.

(*d*) The colouring of the walls and ceilings and of all fittings in the rooms should be carefully considered as affecting the light. This point and the size and position of the windows are especially important in their bearing on the eyesight of the children.

(*e*) The windows should be properly distributed over the walls of the class rooms so that every desk shall be sufficiently lighted. The glass line of the window furthest from the teacher should be on a line with the back of the last row of desks.

These rules are a great advance on the regulations governing ordinary buildings, and are excellent so far as they go, but their want of precision with regard to lighting angles, visible sky, &c., is an eloquent testimony to the need of more exact knowledge of the extent to which such factors affect illumination.

The regulations are even more eloquently silent as to artificial lighting. They require detailed plans and specifications of new schools to be submitted for the approval of the Board of Education, including particulars of such items as sanitary arrangements, ventilation, boundary walls, desks, fireplaces, &c., but artificial lighting is not even mentioned.

With regard to the artificial lighting of buildings generally an architect applies at most only such simple rules as so much candle-power per square of floor space, without regard to the height of lights, the character of the reflection, or whether the globes are to be frosted, tinted, or clear. For the disposition of the lights he would probably rely upon the advice of the electrical or gas fitting firm whose tender is accepted. One would have to search diligently to find in England an architect measuring in candle-feet, and recording for future reference, a degree of artificial illumination which he had found to be both sufficient and pleasing for any given situation. Yet the measurement of illumination by say a Trotter illumination photometer or "illuminometer" is simply a direct reading on the dial of an instrument of about the same size, weight, and cost as a hand camera.

The use of illuminometers would enable architects to invite tenders for electric lighting or gas fitting on the basis of specified illumination in candle-feet at certain points with specified

lamps, globes, &c., and thus secure effects which had been found pleasing and satisfactory elsewhere. At present few architects would have the faintest idea of what illumination in candle-feet to specify at any given point, fewer still would know how to take the necessary simple measurements to see whether they had obtained it. But illumination in candle-feet at certain points (and not candle-power at uncertain points) is precisely what architects are most particularly concerned with. Their province is the result, the means lie in the hands of the engineer. At present architects know a little about the means and nothing at all about the result until they see it. New and economical systems of artificial lighting are constantly being placed on the market and widely used. Whereas a few years ago flat-flame gas lamps and arc and 8 to 16 candle-power incandescent electric lamps comprised practically all systems of lighting, there are to-day a dozen or more well-known systems whose illumination differs from these older ones almost as widely as they differed from candles and oil lamps.

Every day it becomes more important that the architect should be able to specify at least the general distribution of his artificial lighting and the illumination in candle-feet that he requires at every point. Not until he can do this can he compare intelligently the relative advantage and economy of different systems for the particular purpose which he may have in hand. The fact that he cannot do so is not so much his fault as that of engineers and scientists, who in this country have so neglected the science of illumination that the architect has no suitable text-books from which to obtain the necessary information, and very few experts indeed who can assist him. The general neglect of the subject is clearly shown in the curricula of the different architectural schools. An examination of any syllabus shows perhaps one lecture on window areas to third or fourth year students, the subject of illumination from different systems of artificial lighting being ignored as completely as it is in the papers of the qualifying technical examinations.

As the height and extent of buildings tends to increase, the problem of daylight illumination is becoming almost as complex as that of artificial lighting, and methods which when combined with experience are sufficient to predetermine successfully the daylight illumination of, say, a county mansion, can be hopelessly at sea over town schools, hospitals, and libraries, or blocks of buildings covering large areas.

Even if private clients may be satisfied to trust to their architects' skill and experience, the erection of practically all large modern buildings is in the hands of public or semi-public bodies or their building committees, the architect for any large building being almost invariably selected from the result of an architectural competition. Quite properly such committees, as the trustees of other peoples' money, look very closely into all possible details of proposed buildings. Architects need now, and will need even more in the near future, to justify their plans before such committees with regard to illumination as in other respects, and in terms certainly more exact than are in general use at present. Even if unable to state in candle-feet the illumination which, having regard to all the circumstances, will be given by the windows they have designed on the desks of schools, on the tables of libraries and public offices, and in the wards of hospitals with any given degree of sky brightness, they will at least require to be in a position to state definitely whether such illumination will vary from standard existing buildings and approximately to what extent. They should certainly be able to explain in exact terms the illumination resulting from the artificial lighting they propose to employ, instead of merely stating the candle-power and to refer to existing examples of similar illumination. None of these would be particularly difficult problems were the illuminometer added to the everyday working tools of the architect or of the expert advising him.

Disputes as to ancient lights also

present another difficulty to architects and surveyors, which can only be solved by the intelligent use of the illuminometer. The courts are continually in need of expert evidence as to the damage done by new buildings to the daylight illumination of old ones. The character of the expert evidence given in such cases is almost invariably a vague statement of the personal conclusions of each particular expert, unsupported by a shred of scientific reason that a judge and jury can grasp, often betraying ignorance of some of the most essential factors, but always backed emphatically by the lengthy experience, the high professional standing, and the many qualifications of the deponent. It is generally opposed by the diametrically opposite conclusions arrived at by equally eminent experts on the other side. One frequently hears elaborate calculations, illustrated by diagrams, of the proportion of sky which has been obscured, and which was previously visible with the eye say a foot from the centre of the window or even on the glass itself; and the result given as the exact proportion of damage, quite regardless of the large part played by reflected and diffused light in any but purely rural districts.

Visits to the rooms alleged to be damaged are described by experts who found them poorly lit on cloudless days, probably in blissful ignorance of the fact that blue sky is by no means a good condition for the reflected diffused light upon which town premises of necessity largely depend for illumination.

In opposition to this, testimony would probably be borne to wonderful feats of reading minute print performed in the same rooms on cloudy days by professional men of equally unimpeachable character and equally eminent, but who are probably equally unconscious of the extent to which a slight cloudiness *increases* diffused illumination.

Small wonder it is that the Courts are showing growing impatience, and that judges sometimes evince a cynical mistrust of expert evidence given in ancient light cases and not infrequently prefer to visit the premises and form their own opinions.

The problems involved in ancient light cases are really insoluble except by the application of practical photometry, but when so solved they are quite simple. The law first requires to know whether a new building has or has not damaged the light of an existing one, to a degree below that generally obtaining in the surrounding districts, and which is in fact a nuisance. If that is the case it then requires such damage to be stated in terms which can be translated into monetary damages. Every window is simply a means for obtaining a certain proportion of the sky brightness for interior illumination. Windows with an horizon more or less obscured are naturally less efficient illuminators, but their efficiency remains practically constant throughout the wide range of constantly varying sky brightness. If the middle of a room enjoys an illumination of 2 candle-feet with a grey sky brightness of 280 candle-power per foot superficial it will enjoy 0·5 candle-feet with a grey sky brightness of 70 candles. The use of a Trotter illuminometer provided with a daylight reducer will fix for any room in a few minutes the ratio between sky brightness and interior illumination and a comparison showing this "window efficiency" of rooms alleged to be damaged as compared with that of a number of rooms at the same floor level in the neighbourhood can be easily obtained, and is precisely the evidence required by the Courts.

Our knowledge of relative sky brightness over yearly periods is even now sufficiently extensive for an expert to calculate with fair accuracy, the average amount of extra artificial lighting per annum which corresponds to any given loss of "window efficiency." This not only gives in exact terms the most important item of damage, but is a fair criterion of the damage to the general amenities of the building.

The Courts now grant injunctions against the erection of proposed buildings on the ground of possible interferance with existing rights of light in fewer cases than formerly, preferring

generally to allow the erection, and assess damages on completion. Injunctions are, however, sometimes granted in flagrant cases or where the the lights affected are of great importance. Prospective damage is particularly difficult to prove, but in the hands of a competent expert whom the Courts can trust, relative photometric measurements on scale models should form definite reliable evidence of its extent. As it is not easy to prove simply to lay minds that the relative photometric measurements in small scale models are scientifically correct representations of what takes place in full size rooms, it is desirable, in order to convince a judge and jury as to this important point, that the expert should be in a position to detail a number of coinciding measurements taken in actual rooms and in scale models of them.

There is no more hopeful field of investigation to the lighting expert than that of relative photometry and the practical experiences of those who have experimented in it would be of great value to all investigators in illumination. The interesting article on the subject by Dr. Ruzicka, which appeared in the June number of *The Illuminating Engineer*, unfortunately does not detail any actual experiments, and the particulars given of the photometer used are hardly sufficient to enable an estimate to be formed of its value for such work. Apparently, it compares, by direct reading, illuminations which differ by at least as much as 100 to 1, and which would in the models of ordinary rooms differ by as much as 1500 or 2000 to 1; a direct reading instrument giving accurate results over those ranges, and dispensing with the necessity for a standard comparison lamp and a reduction device would be the greatest value. So limited is the range over which the eye is sensible to differences of daylight illumination on white paper that direct comparison over such ranges has, as far as the author is aware, never yet been attempted. The use of the same photometer in the model as is used for the full sized rooms entails somewhat large models, but a scale of 2 in. to the foot, which is not excessive, enables table height readings to be easily made in the model and the use of the same instrument is a ready check upon the accuracy of the results.

Mr. V. R. Lansingh in London.

DURING the last month we have received a visit from another distinguished member of the Illuminating Engineering Society of New York, Mr. V. R. Lansingh, the General Secretary and Treasurer of that Society, and the author of one of the very first books on the subject of illuminating engineering (see *Illuminating Engineer*, Feb., p. 168).

Mr. Lansingh is making a trip through many of the principal cities of Europe with the object of studying the progress of illumination and recent developments of the various systems of lighting in use.

Mr. Lansingh was one of the original three founding members of the Society in the United States, and its progress owes not a little to his energy and experience. We were pleased to hear that the work of the Society is prospering. The list of papers to be read before the approaching Convention, published in our last number, affords ample evidence of its vitality.

While explaining the experiences of the Society in America, Mr. Lansingh spoke encouragingly of the prospects of a society on similar lines in this country. He stated that his American experience led him to the conviction that the lines on which we were working and our efforts to form such a society must ultimately prove successful, and that though some might think that the conditions in the two countries are somewhat different, we, too, would meet and triumph over any initial difficulties that might occur.

Light as a Means of Attracting Attention.

By an Engineering Correspondent.

Probably few people realize the exact reasons why their attention is involuntarily attracted to certain objects in the streets, and why so many others fail to receive any notice though they may pass them on their way to business every day. It is only through the agency of light that the objects surrounding us are seen at all, and it will therefore be readily granted that the illumination of such objects may have more than a little to do with their power of attracting notice.

There can be no question but that the exact qualities in a sign or notice that rivet the attention are very greatly dependent upon the scheme of illumination adopted.

When any object has exactly the same shade of colour and exactly the same brightness as its background, it becomes practically indistinguishable at a little distance. When, therefore, we wish any object to "stand out," and to attract attention, we must secure that either one or the other of these qualities is very distinctively different from the surroundings. The application of such considerations to street-signs, shop-lighting, and advertising problems generally, is obvious.

But there are also a number of cases in ordinary life when the same considerations must come into play, though we may not be aware of them. Let us, for instance, take the case of a man working at a desk in his office. It is a much debated point whether a general diffused system of illumination is the best in such a case or no. This method, a good example of which is seen in Figs. 1 and 2, has certainly several points to recommend it.

It is generally recognized that such systems of lighting represent the nearest approach to natural daylight conditions in which a uniformly diffused illumination from the sky is utilized. The possibility of "glare" from too brilliant sources of light is effectually avoided, and the absence of shadows, such as are often inevitable when more or less "point-sources" of light are employed, is also an advantage in many respects.

On the other hand, many people will be found who cannot tolerate such inverted methods of lighting in any room having any æsthetic pretensions, because they are conscious that the complete absence of shadow makes the room uninteresting. No doubt this is partly to be explained on the assumption that the eye, searching the room for some point of interest, sees nothing that "stands out," and so attracts the attention.

The same feeling may prove a hindrance even when the person in the room wishes to concentrate his attention on the work on his desk before him. For there is no decided contrast in shade between the papers before him and the surroundings, and he therefore does not receive any optical inducement to keep his attention on his work. A very violent contrast to the method of lighting shown in Fig. 2 is that exhibited in Fig. 3.

This illustration is taken from Dr. Bell's recent paper on 'The Physiological Basis of Illumination.' Here the attention of any one entering the room is inevitably attracted to the brightly illuminated table. But, as Dr. Bell explains, the contrast between the brightly illuminated table and the dark surroundings is too severe. Every time the eye wanders from the table it undergoes rapid accommodation to the darkness that amounts to a positive shock, and the ultimate effect is very wearisome.

Probably the best plan of all, therefore, is something intermediate between these two sets of conditions, and the

most perfect condition of affairs would probably be secured by using a moderate general illumination, coupled with stronger local illumination, so as to tend to rivet attention on the table. It may be deemed far-fetched to suggest that such extra illumination can make any difference to the comfort of the worker; but when we remember the importance of such details in the case of a man who is constantly engaged upon exacting brain work for long intervals of time, we can see that such details, however trifling in themselves, are at least worth consideration.

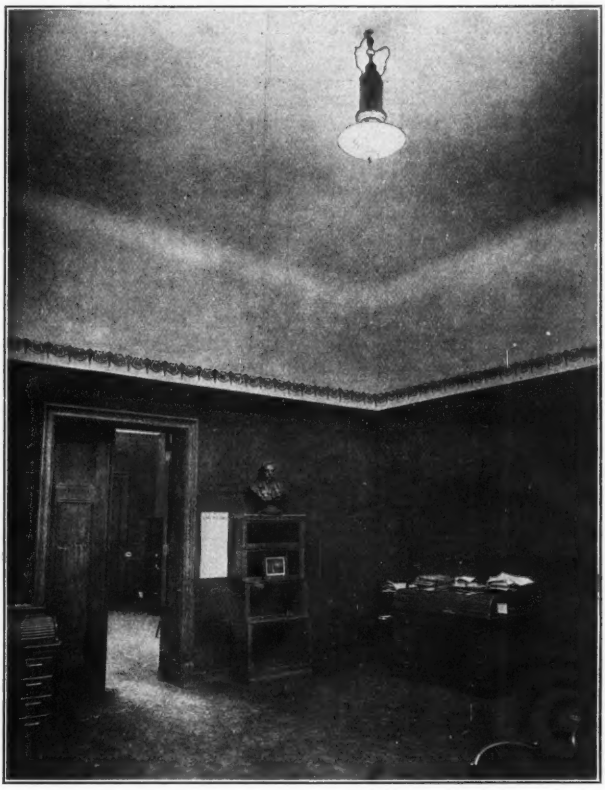


Fig. 1.—General Diffused Illumination by Inverted "Regina" Arc Lamp.

The same principle must apply to lecture-theatres and schoolrooms with even greater force. In such cases we ought to do all that is possible to attract the attention of the audience to the lecturer. We ought therefore to provide sufficient general illumination to enable them to take notes, &c., but we should also make special efforts to illuminate the lecturer's table, or the blackboard or diagram to which he is referring. On the other hand, any diagrams that may be distributed about the room for future reference, ought presumably not to be illuminated to the same extent; otherwise the attention of the audience will be inclined to wander to them. Above all, there must be no bright points of light visible out of the tail of the eye, as such sources of light cannot but have a very distracting effect.

We can easily call to mind many

other cases in which similar considerations apply. In a church, for instance, one would be inclined to suggest that, while a certain general illumination is necessary during the singing of hymns, &c., this illumination ought to be weakened during the sermon, in order to render the specially illuminated pulpit the central point of interest. As a matter of fact this is very often involuntarily recognized, and the lights are turned down at this stage. There are, however, also churches in which the bright sources of light are allowed to fall into the line of sight of any one looking towards the preacher, and thus tend towards somnolence on the part of the congregation.

There are many other cases in which the necessity for making special arrangements to illuminate important objects of interest is not sufficiently realized. It has only recently begun to be appreciated that our methods of giving directions to strangers in our midst, whether they refer to the names of streets and buildings or the nearest railway station, are often sadly defective. And even in cases in which measures were taken to give the necessary information in the daytime, the fact that such notices as had been erected became invisible during the evening was generally overlooked.... except by those who had occasion to search for them. More recently, however, the need for well-illuminated and prominent signs of this description has been more clearly realized, and there are now a number of cases in which such defects have been remedied; of these the illuminated signs adorning many motor-buses and those calling attention to the whereabouts of the Metropolitan Railway stations off the Strand are examples. There still remains, however, very much that might profitably be done in this direction, both in the way of providing directions as to the whereabouts of objects of interest, and also of illuminated explanation signs referring to streets, public buildings, &c.



FIG. 2.—Diffused Lighting by "Regina" Arc Lamps.

As soon as we enter any big building the same want is felt, and if the present arrangements are a very great improvement on those that were considered satisfactory in the past, there is still room for further progress. When entering a railway station, for example, there are always certain things we wish to know and very often want to know in a hurry. We ought therefore to be able to see at a glance where the booking-office is, where the train for a certain place is about to depart, &c., and everything possible ought to be done to cause such notices to strike our attention at once. Well-illuminated direction-signs pointing out the subways to various local stations, &c., are also essential and well repay erection if only by the amount of cross-questioning they save the employees of the company. In the multiplication of such illuminated notices in most up-to-date railway stations we see an illustration that the value of light, wisely used for this purpose, is receiving more attention than a short time ago. An instance of the erection of very convenient illuminated signs of this kind occurs at the Finsbury Park station of the G.N.R., where passengers coming up from the tube and preparing to mount the stairs to the Great Northern station are met by a series of signs which inform them where the next trains are to start from and where they are going. Such instances might be multiplied, but we are still in a process of transition. In one of the tubes which the writer has in mind, excellent direction-signs of this kind abound, but the clocks are not illuminated at all, and appear to the passenger jet-black against a background of diffused illumination.

In commenting on the use of direction-signs in this way, the writer has made special reference to the requirements of railway stations, but it need hardly be said that the same remarks apply to many large buildings where cloak-rooms, ticket-offices, refreshment-rooms, &c., have to be searched out by the visitor.

Although the subject of shop lighting and advertisement lighting generally is too big a subject to be more than briefly mentioned in this article, the application of scientific principles of drawing attention are in this case self-evident. There is no doubt that much more might be done in the way of making such displays striking by carefully studying the method of lighting applied. In this connexion it cannot be too clearly laid down that any effect that is merely disagreeably bright probably defeats its object by making it unpleasant for the passer-by to keep his attention fixed. As a result, his eye, after being involuntarily attracted, turns away in relief to something less wearisome. In shop lighting for instance, where the

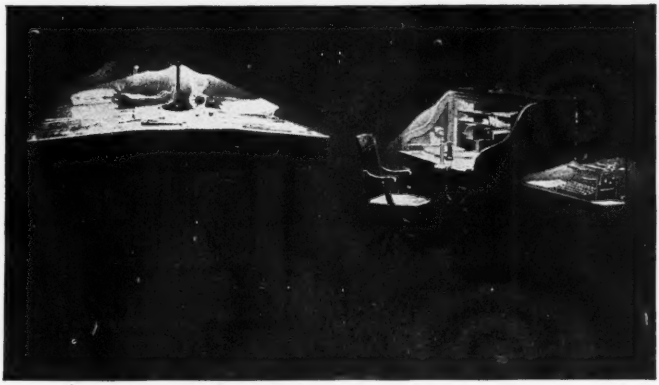


FIGURE 3.
Local Desk-Lighting with Sharp Contrast.

brightly illuminated window both acts as an advertisement in attracting attention and also serves the purpose of displaying goods when the prospective purchaser has arrived, it is generally agreed by those who have studied the subject that bright sources of light must be kept out of the line of sight of any one gazing into the window, and that the lights ought to be effectively utilized for illuminating the goods displayed. If the salesman elects to put some bright lights out of the line of sight above the window as the contents of the window we reach a very important subject that has hardly been adequately touched upon as yet. Considering the pains to which the stage-manager of a theatre is willing to go in order to interest the audience, it will be admitted that the shopkeeper, whose window may be regarded as a miniature stage, might achieve great results by exercising a little similar ingenuity, One question that has been frequently discussed of late is the advisability or otherwise of using a perfectly uniform system of



FIG. 4.—Showing Lights utilized both to Light up Notices and to Illuminate the Contents of the Window.

an advertisement that is another matter.

An ingenious scheme now sometimes adopted is to cause the lights both to illuminate the contents of the window and also to illuminate a semi-transparent device bearing the name of the proprietor of the shop, as shown in Fig. 4. In such a case the same lights are used both for advertising purposes and for lighting the contents of the window, but in a legitimate manner without offending the eyes.

When we come to consider the best arrangement of lights for the display of illumination such as that aimed at in Fig. 5. This is a question which must be felt to depend very greatly upon the nature of the contents of the window. It might be supposed, for instance, that in this particular case, in which a series of hats, all apparently equally important, are illuminated, a diffused illumination is justified because the shopman has presumably no desire to attract attention to one hat more than another. On the other hand, in a case in which it is desired to call special attention to some special object within the window, it might be

advisable to secure this attention by accentuating the illumination of this object, and thus causing it to stand out among the general contents of the window.

Finally a few remarks may be made upon the general conditions that would seem to be necessary in order both to attract and to keep attention. In the first place we may emphasize the point made a few lines above, that though it may be necessary to make lighted signs brighter than their surroundings in order to attract attention, yet it is certainly inadvisable to restrain their brightness below that upper limit above which the eye is conscious of an impression of disagreeable dazzle in order to keep it. From this point of view, signs of the transparency variety would certainly seem to be preferable to those outlined in naked incandescent lamp filaments.



FIG. 5.—General Uniform Illumination.

Also, attention may be called to one point that deserves greater notice than it has received at present, namely the value of colour as a means of attracting notice. As was explained at the commencement of the article, an object becomes indistinguishable from its surroundings when it resembles them exactly, both in colour and brightness. We may therefore often attract attention by making the colour of our sign quite different from anything in its neighbourhood. This would be particularly valuable for purposes of classification. It might, for instance, be settled that all municipal and official notices in the streets should be red or green as the case may be. We should then be in no danger of wasting attention upon an advertisement when we are inquiring our way to somewhere, and, indeed, the multiplication of illumination signs in our streets is proceeding so rapidly, that some such differentiation is already advisable in order to give prominence to certain important notices, among the many bright objects around them. In the same way if red light were invariably used for the illumination of clocks, we should soon fall into the habit of looking for the colour in a railway station or in any other circumstances in which the time is of paramount importance, and our attention would be immediately attracted by the unusual colour.

We have already some illustrations of the use of colour in this way in the red lamps which indicate the where-

abouts of the Fire Brigade or the doctor, and the white letters on a blue ground on the lamps outside the police stations.

The writer has abstained from referring to signs in which attention is attracted by alternately lighting up or extinguishing certain letters, &c. This method of attracting notice by alternation in brightness is of course very effective, but probably should not find application to the variety of signs with which we have mainly dealt. Signs of the purely advertising character form a special class by themselves apart from those intended to supply information. To many people the rapid fluctuations in darkness and brightness entailed by such signs are wearisome, and, as it must be confessed that their power of attracting attention demands a sudden change of this kind, one would hesitate to recommend a very general adoption of this method. The multiplication of flashing devices in our streets would tend to create a feeling of bewilderment and distraction, and would tend to render it difficult for attention to be attracted to notices which were really essential.

In any case our object in arranging the illumination with a view to attracting attention must be carefully borne in mind. We must in some way distinguish the important objects from their surroundings. It is even possible that in the future the relative prominence of illuminated signs will be a matter of definite privilege, and that in situations in which it is absolutely essential that public attention should be fastened upon a certain notice, the presence of other objects likely to encroach on the public attention, and render it possible for the important sign to be overlooked, will be forbidden. The general underlying principles of all such attempts to rivet attention are the same. It is only by means of light that an object is visible at all, and it is mainly by controlling this light that an object is brought into prominence or left in comparative obscurity.

Means of Preventing the Deposit of Moisture on Shop-Windows in Winter.

In the July number of *The Illuminating Engineer* (p. 595) attention was drawn to one qualification of illuminants intended for show-window lighting that is apt to be overlooked. In winter the cold window-panes are often obscured owing to the condensation of the moisture from the heated atmosphere within, and it therefore is best to avoid methods of lighting in which any considerable development of heat and moisture occurs in the processes of combustion.

The June number of *The World's Work* contains a reference to a preparation which, it is claimed, overcomes this difficulty. Windows coated with the preparation are said to remain quite clear, in spite of the difference in temperature inside and out, and the objectionable steaming does not take place.

Low Candle-Power Lamps and Sensitive Meters.

In a recent number of *The Electrical Times* attention is drawn to one point in connexion with electric meters that has arisen since the introduction of the new high-efficiency lamps. The starting-current of meters ought now to be kept down to a lower value than was formerly considered necessary, owing to the fact that lamps are now in use taking such a small current as to fail to be recorded by the meter at all.

For instance, on a 200-volt circuit a 30-candle-power tungsten lamp may have no effect on the meter, while on low-pressure circuits it would probably be difficult to find a meter capable of registering a single 6 candle-power lamp, unless assisted to do so by transformer losses. The consumer would therefore be at liberty to keep one light on for nothing.

Some Effects of Light, Visible and Invisible.

THE unfortunate experiences of Dr. Hall Edwards, and of many other early workers in the subject of X-rays, illustrate only too clearly how cautious should be the investigator of some new and untried form of energy, which may produce after-effects quite unsuspected at the time of the experiment. Unfortunately, too, these bad effects frequently only gradually reveal themselves when prolonged exposure has already done the mischief. Even today we are discovering new and peculiar qualities of these rays. Recently, for instance two French investigators, MM. Imbert and Marques, described a curious experience in their laboratory.

It was remarked that the hair and beard of one of their colleagues, long since turned completely white, were gradually returning to their pristine colour. Eventually this colour became even more striking than it had been originally. Subsequent experiments are said to have fully confirmed this remarkable effect; the change in colour was also apparently quite permanent. It is possible, therefore, that a cure for prematurely whitened locks is at length at hand; yet, in view of the ill-effects which may follow incautious exposure to these rays, one would hesitate to recommend its use, except under careful supervision.

During the last few years considerable attention has been paid to the physiological influence of another more frequently encountered form of radiation—the so-called "chemical" or 'photographic" rays in the spectrum. Our eyes are only responsive to a certain range of frequency of the waves in the ether, which we call "light." Just as, in the case of sound, we recognize a certain number of octaves of musical sound, while higher or lower vibrations degenerate into mere noise, and eventually become inaudible, so, in the case of light, only the waves of a certain range of frequency are visible to the eye. They may, and do, however, possess other very vital properties by which they are readily detected in other ways. Rays which are of too high a frequency to be perceived by the eye, for instance, readily produce chemical action, and are thus perceived by the photographic plate in a camera. They even produce well-marked physiological changes, and the development of the methods of production and uses of this kind of energy forms one of the most interesting series of results of the last and the present century.

It is, perhaps, not generally known that sun-burning is now understood to be due, not to the mere heat of the sun, but to the photographic action of these invisible rays. This so-called photographic action is very curiously illustrated by the marking which follows small-pox. The discovery of this fact by Finsen led to the subsequent use of these rays for the treatment of skin diseases. Far back in the Middle Ages it was believed that, for some reason, it was beneficial to surround persons suffering from small-pox with red curtains. This impression was in some cases ridiculed by scientists, and it is only quite recently that it has been demonstrated that such curtains were really actually beneficial because they absorb the chemical rays. For the severe marking following small-pox was found to be actually due to a photographic effect — the disfiguring marks being permanently stamped or printed in on the exposed part by the chemical rays. If, however, such rays are carefully excluded from the patient until he is convalescent, the subsequent disfigurement is much less severe.

The discovery of this fact led Finsen to attempt to produce the chemical rays, or, as they are usually termed, "ultra-violet" rays, in greater quantities than they actually exist in sunlight. For this purpose he developed a very concentrated electric arc-

lamp. By means of this apparatus he could readily produce all the effect of sunburn by an exposure of only a few minutes. At the present time it is a common experience of those who are constantly working with powerful arcs —searchlights and so on—to become sunburned in this way. Indeed, unless care is exercised the effect takes place with an emphasis which is distinctly uncomfortable, causing the skin of the part affected to peel off exactly as in cases of severe sunburn.

Afterwards the curative effect of exposure to ultra-violet rays of parts affected by various skin-diseases was discovered. The ultra-violet rays have long been definitely proved to exert a marked destructive action on bacteria; it seems to be now regarded as very probable that these rays, even under ordinary circumstances, exert an important influence on the skin and blood. There has even been a suggestion that the inability of the negro to withstand the tubercle bacillus is due to the blackness of his skin, which absorbs ultra-violet light before it can do more than penetrate the very outermost layer of the epidermis.

As soon as the valuable qualities of ultra-violet light were generally realized, efforts were made to secure sources of light richer in energy of this description than the ordinary Finsen arc. The percentage of the total amount of energy put into the ordinary carbon arc light which actually comes forth in the form of ultra-violet light is very trifling—a mere fraction of 1 per cent. Naturally, therefore, the production of chemical rays in this way was very costly and inefficient. A distinct improvement was effected by employing iron electrodes, it having been found that incandescent iron-vapour is very rich in the required form of energy. More recently, electrodes of special chemical composition were utilized with yet more favourable results, but still the percentage of the desired form of energy generated was miserably low. But during the last two years a new and entirely different source of ultra-violet energy, which is said to possess wonderful properties, namely the mercury lamp, has come to the front.

The use of tubes of incandescent mercury vapour as a source of light—*for purposes of illumination*—is of older date; a number of these lamps, shedding their characteristic curious green light, are to be seen in the streets of London to-day. In the case of these lamps the enclosing tube was made of ordinary glass, which very completely absorbs the ultra-violet rays. They were therefore of service for the generation of *visible* light only. But the discovery in Germany of varieties of glass which let through ultra-violet light revealed the possibilities of the mercury light in this direction. Lamps having tubes composed of these new quartz and other glasses are now actually constructed, and it is said that as much as 30 per cent of the power given to the lamp, as opposed to a mere fraction on the part of the sources previously mentioned, is actually available in the desired form.

Such lamps appear to be extraordinarily powerful. They are expected to prove of great service for medical purposes, such as the treatmen of skin diseases, the destruction of bacteria, and for sterilization generally. In this connexion it is interesting to learn that they have, apparently, a peculiarly deadly effect on small insects. It is said that a fly, when brought within an inch or so of the lamp, is killed immediately. The lamps are also regarded as of very great value for photographical purposes. One very interesting instance of their strong chemical action is as follows. The fading of carpets, and coloured objects generally, when exposed to bright sunlight, is now understood to be caused by the chemically disintegrating action of the ultra-violet element in daylight. For this reason we are told that the manufacturers of coloured goods in the north of Germany have found it necessary to send their goods south, to regions which are more liberally treated in the matter of sunshine, in order that the permanency of the colours employed might be effectually tested. But it is now suggested that this will be no longer necessary. The testing will be accomplished by means of the new mercury

lamps, and that, too, in a mere fraction of the time formerly required.

It seems, therefore, that we have now at our disposal sources of ultra-violet energy far more powerful than were dreamt of a few years ago. That they will be invaluable for certain specified purposes can hardly be doubted. But we must also bear in mind the necessity for care on the part of experimenters, just as in the case of the X-rays mentioned at the commencement of the article. We would naturally suppose that ultra-violet light, which is credited with such wonderful powers in a curative direction, would also exercise marked influence upon the unprotected healthy individual. This seems to be the case. Fortunately it seems that the most injurious effects make their appearance relatively soon after exposure, and are therefore readily detected.

Ultra-violet light, as we have seen, produces "sunburn." In very great quantities even an exposure of a few seconds may produce a distinctly uncomfortable inflammation of the skin. Of much greater consequence, however, seems to be its effect on our visual apparatus. There are many cases on record where very serious inflammation of the eyes was experienced by those who had been working with powerful naked arc lamps. These bad consequences have been definitely traced to the presence of the strong ultra-violet element in the light from the arc lamp, originally remarked, as we have seen, by Finsen. It is significant that some of the most serious of these cases have occurred when arcs of very high power were being used for the purpose of drilling iron plates; luminescent iron-vapour, as we have remarked before, is exceptionally rich in ultra-violet rays.

Another instance of the effect of ultra-violet energy is afforded by cases of snow-blindness. The atmosphere of our earth is very effective in suppressing rays of this nature, and consequently sunlight, in the form in which it reaches us, only contains a comparatively small percentage of such energy.

On the mountains, however, the light from the sun is in a very different condition, because it has not suffered to the same extent owing to the intervening atmosphere. Moreover, the relatively strong ultra-violet element present is being constantly reflected hither and thither by the snow, and is thus able to enter the eye in directions very different from those in which it arrives in the ordinary course of events. It is therefore found that irritation, ultimately culminating in snow-blindness, is liable to occur if precautions are not taken to screen the eyes by suitable glass spectacles.

In all the cases the injury to the eyes is not felt immediately at the time of exposure, but only makes its appearance after a few hours have elapsed. Fortunately it seems to be fairly easy to guard against this injury by covering the eyes with thick glass goggles. But in the case of the extremely powerful sources which are now available, very special precautions are desirable, and special varieties of glass for the use of operators have been recently put upon the market.

It has even occurred to some engineers to raise the question whether the comparatively small quantities of ultra-violet energy present in ordinary illuminants, such as electric glow-lamps and incandescent mantles, may not be injurious. There is certainly a tendency in our modern illuminants towards higher temperature and consequently towards an increasing percentage of radiation of the character referred to. The present practical illuminants appear to yield but a very trifling percentage, but the older types, the candle and the oil-lamp, probably contained even less.

Schanz and Stockhausen (*Illuminating Engineer*, Jan., p. 70) have quoted the suggestion that cataract may be caused by the action of ultra-violet light on the lens of the eye, and have instanced the work of previous investigators who have observed a distinct turbidity of the lens under the action of the rays. However, common experience suggests that the danger of injury in this way is not very generally experienced.

One frequently hears vaguely expressed suggestions that the spectral character of the light given out by certain illuminants results in their being specially fatiguing to the eyes, and this is ascribed to the effects of ultra-violet light. There are, however, so many other factors that enter into the problem, and may individually be responsible for such effects—such as the concentrated brilliancy of the light for example—that it is mpossible to make any very definite suggestions on this point at present.

We must remember, too, that the glass globes which surround ordinary sources of light are all more or less effectual in destroying even such ultra-violet element as exists.

On the other hand, there is always the possibility of new illuminants (intended for ordinary purposes of illumination, but infinitely more powerful in this respect than any employed in the past) coming upon the scene. From the reports to hand at present it appears that the new Küch quartz tube lamp recently brought out in Germany is an example of such a lamp (*Illuminating Engineer*, January, p. 81), and it has been found necessary to surround the lamp with an envelope composed of glass of a special character capable of completely absorbing the dangerous rays.

It should also be borne in mind that when a person is working continuously by artificial light, effects which are in themselves comparatively trifling may, in the long run, have a cumulative result that is anything but insignificant.

J. S. D.

(*To be continued.*)

Illumination of Test-Type Charts by Artificial Lights.

(From the *Optical Journal*, June 11.)

Dr. Norman M. Black recently discussed the above question in a paper before the Academy of Ophthalmology, Louisville, Ky., U.S.A.

He explained that the conditions affecting daylight illumination differ so greatly at different parts of the year that some constant artificial illumination must take its place for the purpose of tests of visual acuity.

Of these he regarded electricity as the most convenient, as practically every city of sufficient size to support an ophthalmic surgeon was lighted by electricity; petroleum and illuminating gas and acetylene-gas were equally efficient from the standpoint of candle-power required, but less satisfactory to manipulate.

The committee appointed by the Ophthalmic Section of the American Medical Association to determine upon a standard of illumination for test-type charts would submit a full report upon this subject at the Chicago meeting next year.

Artificial illumination may be used in two ways, either reflected or transmitted. There was considerable difference in opinion throughout the United States as to the efficiency of these two methods, and an inquiry was circulated with the object of obtaining an expression of opinion from the leading ophthalmologists.

Sixty-two replies were received, and were classified as follows: 18 preferred reflected light, 9 preferred transmitted light, 5 used daylight only, 3 found practically no difference, 25 had had no experience with transmitted light, 1 had no opinion to offer. One question as asked was not answered.

A number of these replies are quoted, without, however, seeming to elicit any very conclusive evidence that either system is greatly preferable from the ophthalmological standpoint.

Dr. Black, however, quotes the statements of a number of American authorities to the effect that yellow light is best for the eyes, and is himself of the opinion that transmitted light is best for the illumination of test-types.

The Cost of the Lighting of the City of London.

(Extract from Report on Works executed by the Public Health Department of the Corporation of London during the year 1907.)

By Frank Sumner, M.Inst.C.E.

Gas Lighting.

Under this heading the report contains two complete tables showing the consumption, lighting-hours per annum, and annual and quarterly charge per lamp throughout the year in the streets of London.

From January 1st to June 30th the Gas, Light and Coke Co. supplied gas at 2*s.* 2*d.* per 1,000 cubic feet, this charge being subsequently increased to 2*s.* 5*d.* from July 1st to Christmas in the case of public lamps north of the Thames.

Incandescent Gas Lighting.

The number of gas lamps (including experimental lamps) paid for by the Corporation at the end of the year was 2,765, being a decrease of 39 during the year, accounted for by the removal of a number of lamps in the side-streets adjacent to the thoroughfares lighted by experimental electric lamps.

The size and character of these lamps (2,765) are set out in the following table :—

TABLE I.

Back Lamps.	Columns.	Brackets.	Lantern.		Ordinary Burners.									High pressure.						Special.	Total.
			Sq.	Cir.	3	4·25	4·25 1/3	4·25 2/3 (Cubic	6¾	7¾	8·50	12·75	21·25	10	20	30	100	15	60		
									feet		per	hr.)		(Cubic feet per hr.)							
66	555	2,144	2,678	87	10	1,972	71	477	1	39	56	5	1	42	45	8	1	1	6	30	2,765

In July two double burner incandescent gas lamps were fixed in Fore Street, by Red Cross Street, to better light the entrance to the public way through Cripplegate churchyard, in lieu of one electric arc lamp removed.

High-Pressure Incandescent Gas Lighting.

In January a double burner high-pressure lamp was fixed on the rest by Nos. 1 to 4, Lombard Street, in place of an electric arc lamp, and one electric light arc lamp at the corner of Lombard Street and St. Swithin's Lane was removed, for which an ordinary single burner incandescent lamp was substituted.

The number of defective gas lights observed and reported upon during the year was 2,278, viz., 1,843 ordinary and 435 high-pressure lamps.

The details of lighting defects in the ordinary incandescent lamps were as follows :—

Feeble lights..	1,485
Lights went out	12
Not alight during night ..	14
Total	1,511

In addition, 332 defects in the lanterns and burners were reported to the Gas Light and Coke Co., and rectified.

The details of the total defects observed in the ordinary lamps during the year are as follows (Table II.) :—

The readings of the meters attached to the public lamps in various parts of the City show that the full contract quantity of gas is given at those lamps, and I am of opinion that the contract quantity is given generally throughout the City, and that the regulators of the lamps are kept in proper condition.

The public gas lamps were lighted, in accordance with the general instructions in force for many years past, whenever fog or unusual darkness occurred. This happened on thirty-

three days during the year, and entailed an additional cost of £219 2*s*.

Electric Lighting.

The lighting of most of the main thoroughfares of the City by arc lamps was continued throughout the year. The number of the older type electric lamps in lighting at the end of the year, at a cost of £26 each, was 400, being a decrease of 39, mainly accounted for by the substitution of the new and cheaper flame arcs, fitted up experimentally by the two Electric Lighting Companies, in November. These lamps were lighted on nine days during the year when fog or unusual darkness occurred, at a total additional cost of £43 12*s*. 11*d*.

The number of defective electric lamps observed during the year was 99. The returns of these defects are made daily to your engineer by the police; for which the City of London Electric Lighting Company were fined for each failure, the amount deducted from their account in fines during the year being £24 4*s*. 11*d*.

Removal of Arc Lamps.

During the year arc lamp "H 37" was removed from the east side of Adelaide Place, the light from the adjacent high-pressure gas lamp being sufficient to light this part of the thoroughfare.

In addition, the following arc lamps have been removed during the year, and gas lamps put up in lieu thereof:—

Rest by Nos. 1 to 4, Lombard Street.

Corner of Lombard Street and St. Swithin's Lane.

By No. 76, Cannon Street.

By No. 1, Fore Street, Cripplegate.

In Table III. is given the number of arc lamps in lighting on the 31st of December, with the annual cost of the same:—

TABLE II.

Defective Lights.			Defective Lanterns.							Total.
Feeble Light.	Light went out.	Not alight during night.	Bottoms.	Tents.	Sides.	Doors.	Dirty.	Protectors.	Burners.	
1,485	12	14	52	10	40	5	70	111	44	1,843

The total number of public electric lamps of all kinds in lighting on December 31st was 451, against 449 on December 31st, 1906.

Experimental Lighting.

In accordance with the Resolution of the Court of Common Council of July 25th, permitting the two Electric Lighting Companies, having statutory powers in the City, to experiment with the newest form of electric lamps for street lighting in the thoroughfares of Holborn, Holborn Viaduct, Old Bailey (part of), Farringdon Street, Newgate Street, and Cannon Street (between St. Paul's Churchyard and Dowgate Hill), the Charing Cross and Strand Electricity Supply Company proceeded with the lighting of their portion, viz., Cannon Street, by erecting 11 magazine "Flame" arcs, 5 of the "Oliver" type and 6 of the "Gilbert" make, centrally hung, being suspended over

TABLE III.

No. of Lamps.	Description.	Price per Annum. £ *s*. *d*.	Company.
400	Original type	26 0 0	City of London E.L. Co.
1	"Oliver" flame arc at Lothbury ...	17 10 0	Ditto.
21	"Oliver" flame arc (experimental) ...	17 10 0	Ditto.
18	"Reason" enclosed arcs (experimental)	12 10 0	Ditto.
6	"Oliver" flame arcs (experimental) ...	17 10 0	Charing Cross Co.
5	"Gilbert" „ („) ...	17 10 0	Ditto.
Total 451			

the roadway by wires attached to the buildings on either side; these wires were subjected to a very severe test, by dead weight and a drop weight, considerably heavier than the lamp. The lamps were put into lighting on November 21st, and will be reported upon in six months' time.

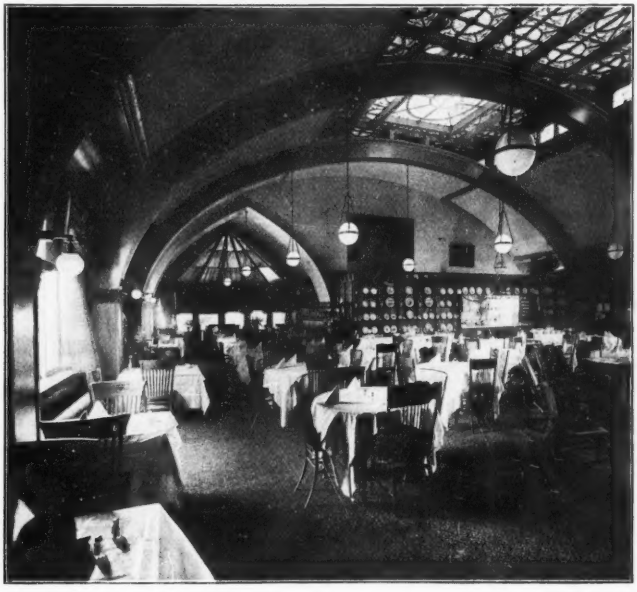
The City of London Electric Lighting Company also proceeded with the carrying out of their experiment by substituting 21 "Oliver" flame arcs for a similar number of the original arcs, adapting the existing columns in Holborn, Holborn Viaduct, and part of Old Bailey, whilst in Farringdon Street 18 enclosed arcs of the "Reason" type were fitted up on special short columns in lieu of the 12 original arc lamps and columns in that thoroughfare. The installation of this area was completed by the 20th of November.

The maintenance cost of the "Oliver" flame arcs in the Holborn area is £17 10*s.* each per annum, being equivalent to the Charing Cross Company's charge in Cannon Street, and the cost of the enclosed arcs in Farringdon Street is £12 10*s.* each per annum.

A Restaurant Lighted with Holophane Globes.

THE illustration below represents an interesting and tasteful method of producing a uniformly distributed illumination over the tables in a restaurant in the United States.

The lighting is achieved by distributing incandescent lamps within Holophane globe reflectors, of the type described in *The Illuminating Engineer* for August (Fig. 3, p. 655).



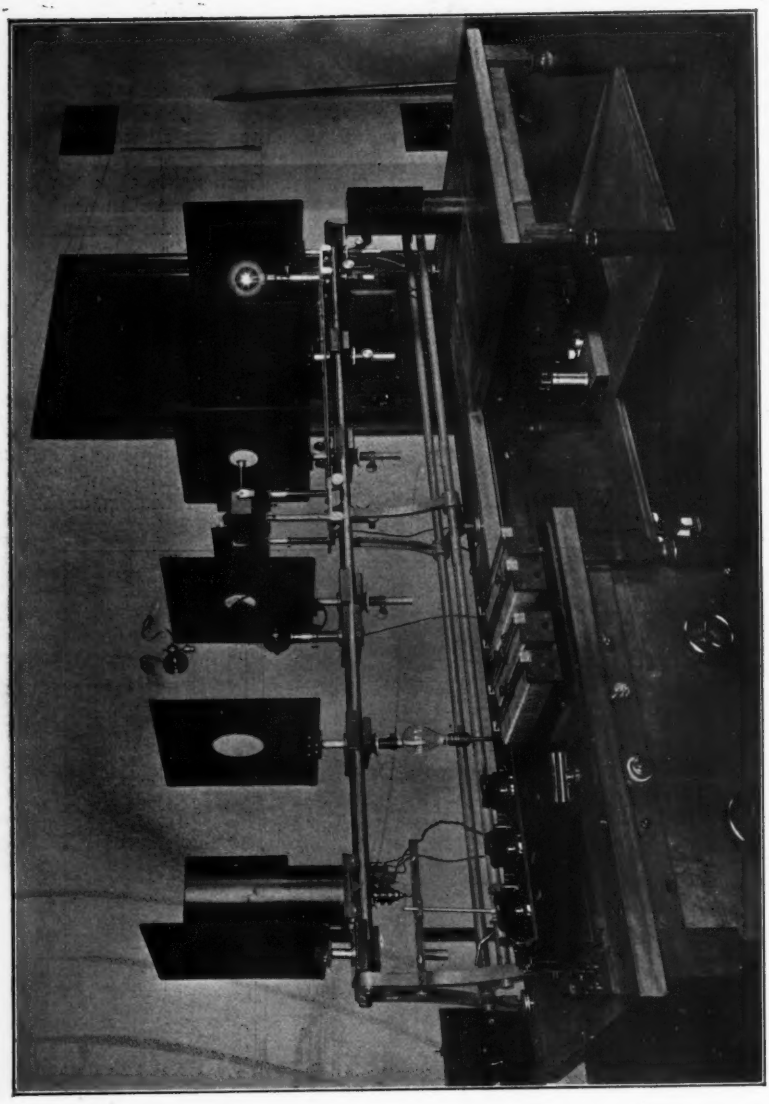


FIG. 1.—Standard Photometrical Bench, The Bureau of Standards, Washington.

SPECIAL SECTION.

Some well-known Photometrical Laboratories.

I. Photometry at the United States Bureau of Standards.

By EDWARD P. HYDE.

ON July 1, 1901, in accordance with an Act of Congress passed the preceding March, the Bureau of Standards was established to supersede the old office of Standard Weights and Measures, which prior to that time, in a restricted way, had performed the functions of a national standards laboratory. By the terms of the Act the functions of the new Bureau were to "consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connexion with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests, and are not to be obtained of sufficient accuracy elsewhere."

From a humble beginning with a personnel of fourteen men, and with temporary quarters in the buildings of the Coast and Geodetic Survey, the Bureau of Standards has developed into an institution with a force of 110 employees, and occupying three new laboratory buildings situated on a $7\frac{1}{2}$ acre tract in the north-western suburbs of Washington.

The work in photometry was inaugurated in the autumn of 1902 in one of the basement rooms of the Coast and Geodetic Survey building. For nearly two years it engaged the attention of only a single laboratory assistant; but in the spring of 1904 the photometric section moved to more commodious quarters in the new Mechanical Laboratory, and since that time the growth has been more rapid. At present the work is carried on by an associate physicist, two assistant physicists, a laboratory assistant, and a laboratory apprentice.

Equipment.—The photometric equipment consists of one standard photometer, one Matthews integrating photometer, one commercial photometer, one spectrophotometer, and various auxiliary photometric and electric apparatus, which will be described briefly in the following paragraphs.

The apparatus is mounted at present in two rooms $9 \times 6 \times 3{\cdot}7$ meters, and $4{\cdot}8 \times 4{\cdot}8 \times 3{\cdot}7$ meters respectively, but recently a third room $8 \times 5{\cdot}5 \times 3{\cdot}7$ meters has been assigned to photometric work. A special feature of all of the laboratory rooms is the provision that has been made for a partial control of the humidity. Each laboratory is provided with a coil of pipe through which cooled brine is made to flow, and by passing the air of the room over this brine coil by means of a fan, the humidity can be reduced greatly.

The Standard Photometer Bench (Fig. 1) is used in all work on standard lamps, and in the investigation of special problems. The photograph from which Fig. 1 is made was taken when the bench was set up for the investigation of Talbot's law, in which Nernst glowers, covered by cylindrical

hoods, were used as sources. One of the hoods is shown in position; the other is sitting on the table beside the bare filament.

The bench is of the Reichsanstalt pattern, supplied with a Lummer-Brodhun contrast screen. By the use of a sufficient number of diaphragms covered with black velvet and suitably placed, stray light is excluded to such an extent that the leakage of light into the photometer screen is entirely negligible, although the walls of the room are of a light colour. The comparison lamp, on the right, is mounted on a carriage which is connected by means of adjustable links to the carriage supporting the photometer screen. The comparison lamp thus moves with the screen, remaining at a constant distance from it, so that the illumination on the right side of the screen remains constant during a series of measurements.

The standard and test lamps are placed successively in the socket on the left, and measured either stationary or rotating as occasion may demand. The horizontal rotator (shown in the photograph with the driving shaft disconnected) was designed and constructed at the Bureau. It has four rotating mercury contacts—two for current and two for voltage. The shell and the base of the socket are each divided into two parts, insulated from each other, to one of which the current lead is connected, and to the other the potential lead. In this way the voltage is measured on the base of the lamp, reducing greatly any error that may be due to a bad contact between the base of the lamp and the socket.

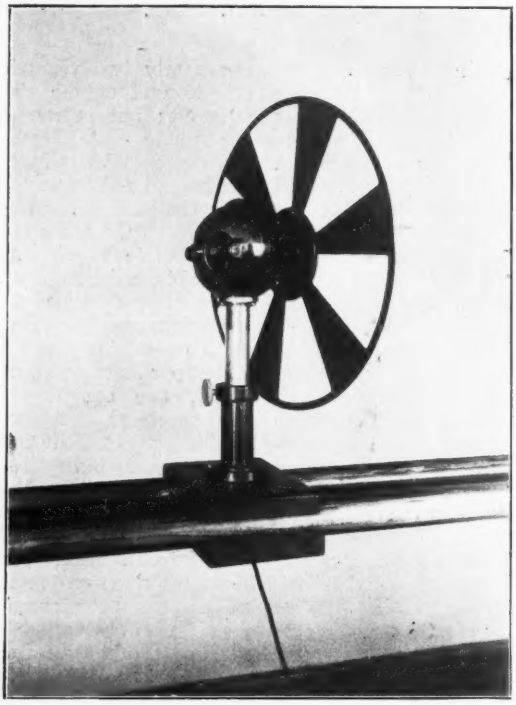


Fig. 2.—Rotating Sector Disc.

The sectored disc shown in the photo-

graph is used, when rotating, to reduce the apparent intensity of a source by a known amount. In Fig. 2 it is shown on a large scale, mounted directly on the shaft of a small motor in the way in which it is generally used.

All of the electrical measurements are made by means of a potentiometer in terms of a Weston standard cell. The voltage of the lamps is reduced by a suitable multiplier, and current is determined by the fall in potential across a standard resistance. By means of a convenient multiple switch mounted in front of the potentiometer, voltage or current on either lamp can be determined quickly with an accuracy of one or two parts in 10,000. The galvanometer is mounted on the wall several feet behind the bench, but the spot of light is focussed on a graduated scale right behind the potentiometer, and at a convenient height for observation.

A new universal support and rotator recently constructed at the Bureau (Fig 3) may be mounted on one of the standard carriages belonging to the bench, for determining distribution curves around incandescent lamps. This instrument may be used either as a universal rotator, or as a universal lamp holder, since it is provided with two graduated circles in planes perpendicular to each other. A lamp may be set quickly to any latitude and azimuth, with an accuracy of a fraction of 1°. The axis of rotation is horizontal, making possible the use of mercury contacts. Any lamp from 4 c.-p. to 100 c.-p. can be measured, and many types of reflector shades and diffusing globes can be mounted with the lamps. By means of an adjustable counterpoise the instrument is always in equilibrium, and therefore free from mechanical strains.

In Fig. 4 is shown the Integrating Photometer for the direct measurement of mean spherical and mean hemispherical candle-power of incandescent lamps. It is of the Matthews pattern modified in theory and construction. It is 10½ft. high, and is provided with twenty pairs of mirrors. It is installed in a room by itself, and although the walls and floor are as nearly dead black as could be procured conveniently, black velvet has to be used freely in order to eliminate stray light. The black velvet was removed when the photograph was taken.

The instrument is provided with a Lummer-Brodhun contrast photometer screen. The test lamp is mounted in a special form of rotator which has two sockets—one upright and one inverted, so that the new types of lamps with weak filaments can be mounted and even rotated at a low speed. The comparison lamp is moved to and fro by means of a graduated steel tape on which the distance is read. Voltage is measured on a laboratory standard voltmeter, and current by means of a millivoltmeter and shunt.

The Commercial Bench (Fig. 5), set up in the same room with the Standard Photometer, is used principally in testing samples of lamps purchased by the Government departments. This bench was specially designed and constructed in the instrument shop of the Bureau. The horizontal rotator, mounted on the left, was purchased from the General Electric Company. It is equipped with the ordinary treadle for reversing the direction of rotation, so that lamps can be spun into and out of the socket. To the left of the horizontal rotator is a special end-on rotator made at the Bureau, for the purpose of determining the candle-power of lamps in the direction of the tip, since this is frequently specified in the purchase of incandescent lamps. This end-on rotator is driven by means of a belt running over a pulley on the vertical shaft of the horizontal rotator, so that both are driven by the same motor, and at the same speed, direct and reversed. Both rotators are provided with mercury contacts.

The comparison lamp is mounted in a fixed position at the other end of the bench, and the voltage on this lamp is adjusted until there is a balance against the standard lamp when the photometer screen is placed at 16 c.-p. or at the proper point on the scale corresponding to the candle-power of the standard lamp. The screen is moved to and fro over a limited

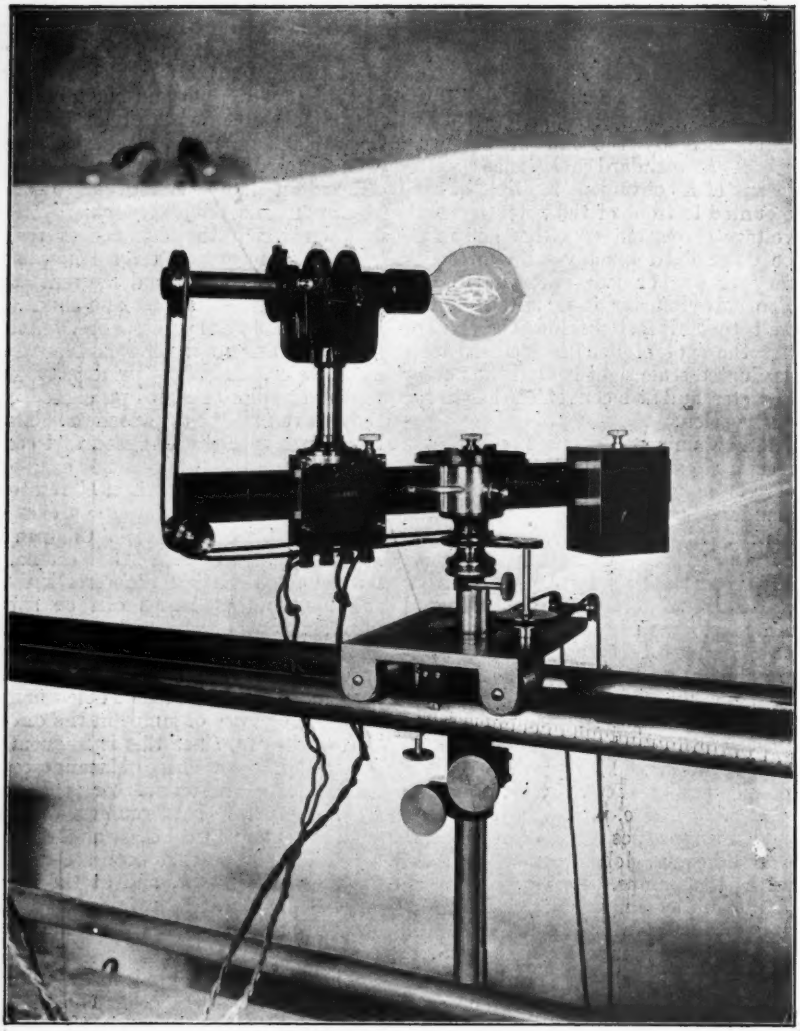


FIG. 3.—New Universal Support and Rotator for Glow-Lamp Tests.

distance by means of a belt operated by a wheel situated under the table, and in a convenient position for the hands of the observer.

A new feature of this bench is the multiple candle-power scale, which, in conjunction with a variable rotating sectored disc, permits of direct candle-power readings for lamps of all intensities, without moving the photometer screen over any great range of distance. One of the pieces of steel tubing forming the track is slotted, and within this tube is mounted a rotating drum graduated with five or six different candle-power scales, and operated by means of a thumb-screw. By turning the drum the desired candle-power scale can be brought beneath the slot. If 50 c.-p. lamps are to be measured, the variable disc is set to the proper angular opening and rotated, and the 50 c.-p. scale is used. The intensities of lamps in the neighbourhood of 50 c.-p. can then be read directly without moving the photometer any considerable distance from the central position. This latter feature is a distinct advantage, on the ground both of accuracy and of convenience. When lamps of a lower candle-power than 16 are to be measured, such as 8 c.-p. or 4 c.-p. lamps, the sectored disc is placed on the other side of the screen, between it and the comparison lamp.

The voltage measurements are made by means of a deflection potentiometer recently designed at the Bureau by Mr. H. B. Brooks. With this instrument the voltage can readily be adjusted to 0·1 volt or better in less time than it takes to make a corresponding adjustment with a voltmeter, and the accuracy of the instrument is much higher. The energy supplied to the lamp is measured on a Weston wattmeter. This instrument in connexion with a variable resistance controlled by the position of the photometer screen permits of direct readings of watts per candle. In series with the pressure circuit of the wattmeter are two resistance blocks bridged by a sliding contact fastened on the moving carriage which holds the photometer screen. The resistance in series with the pressure circuit of the wattmeter is always such for any position of the photometer screen that the watts are cut down in inverse proportion to the candle-power, so that the wattmeter indicates watts per candle directly.

In the new room which has recently been assigned to photometric work, another photometer bench will be installed within the next few months. The plans for this bench, which will be constructed in the instrument shop of the Bureau, are being drawn up now, but not sufficient progress has been made to warrant any description at this time.

The small amount of life-testing of incandescent lamps which the Bureau has undertaken in the past has been one on direct current, but a 40 kilowatt alternating-current generator has recently been installed for this work, and plans are now in progress to increase the capacity of the life-rack from 200 lamps to 500 or 1,000. The life-racks are not located in the laboratory rooms, but in a sepearate large room in the attic.

In addition to the several complete photometer benches which have been described there is much auxiliary apparatus which constitutes an important part of the equipment. A Brace spectro-photometer with a special form of variable sector made by Franz Schmidt and Haensch of Berlin from designs by Prof. Brodhun is provided for studying the spectral distribution of light from radiant sources. Flicker photometers of both the Simmance-Abady and the Franz Schmidt and Haensch forms have also been secured. An order has recently been placed for a large spectro-photometer of the Lummer-Brodhun type, together with a Lummer-Brodhun sectored disc, the opening of which can be varied and read while the disc is rotating.

As stated in previous paragraphs, the Bureau has a number of sectored discs of fixed opening, and two or three of variable opening of the ordinary form, ranging in opening from 0° to 180°. In addition to these there is one special variable-opening disc that was constructed by W. and L. E. Gurley upon designs furnished by the Bureau.

This disc is composed of two principal component discs, each having a fixed opening of 300°, and a number of very thin auxiliary discs whose only function is to close the gap formed between the two principal discs when these are moved over one another in such a way as to reduce the angle between their calibrated edges. Between 300° and 240° this fan-like set of very thin discs does not come into play, but when the angle between the calibrated edges of the two principal discs is made less than 240° the discs no longer overlap, so that there is an opening between the other edges. This opening is covered by the auxiliary discs. The total range of the disc is from 0° to about 300°. It is calibrated not only in degrees but in per cent. of total opening, and also in candle-power for use in the industrial photometry of incandescent lamps.

The standard lamps of the Bureau constitute an important part of the equipment. These include five Hefner lamps, two Vernon-Harcourt 10 c.-p. pentane lamps, one Carcel lamp, and a large number of incandescent lamp secondary and working standards.

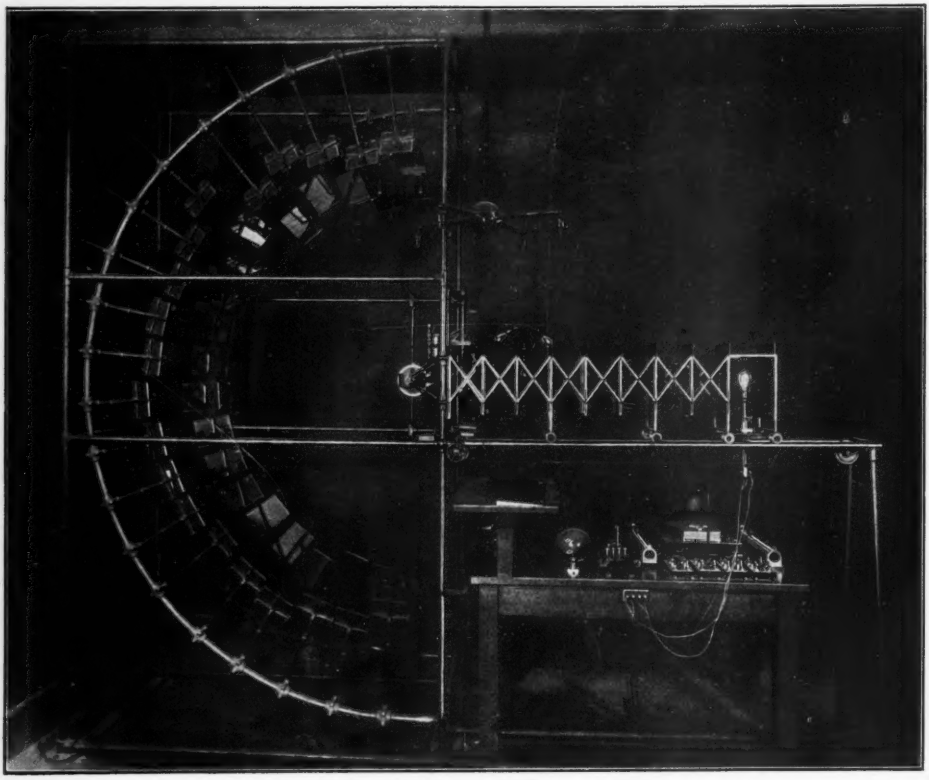


FIG. 4.—Matthews Integrating Photometer.

Testing.—The work in photometry may be classified roughly under two general heads: testing and investigation. An important function of the Bureau is to verify standard lamps for lamp manufacturers or testing laboratories. The Bureau does not undertake at present to supply standard lamps, or to season new lamps for use as standards, but if seasoned lamps

are submitted they are standardized at a nominal fee.

The question is frequently asked, "What standard of candle-power is used at the Bureau?" Although the Bureau has adopted a definite unit of candle-power, which it maintains through incandescent lamp secondary standards, it has not as yet adopted a primary photometric standard. This fact should be emphasized, as it is sometimes stated erroneously that the Bureau has adopted the Hefner lamp as the standard. Neither the Hefner nor any other lamp has been or will be adopted as a primary standard until the various lamps that have been proposed as standards have been investigated thoroughly. What has been done has been to adopt a unit of candle-power which bears a certain ratio (100 : 88) to the Hefner unit as maintained at the Reichsanstalt. At the time of the inauguration of the work in photometry at the Bureau this seemed to be the best way of arriving at the English parliamentary candle, which was supposed to be the common unit of candle-power in the United States both for gas and electric lamps. Inasmuch as the unit can probably be maintained constant through incandescent lamp secondary standards for an indefinite period, the adoption of a primary standard, though important, is not immediately urgent.

This distinction between a unit of light and a standard of light in terms of which the unit is expressed, has suggested the possibility of international agreement upon a common unit of luminous intensity for England, France, and the United States. The units in use in these three countries are so nearly alike that no serious results would follow a compromise by which all three countries would agree upon a common unit of candle-power. The suggestion is, that without in any way involving the question of primary standards, England, France, and the United States shall agree upon a common unit of candle-power which shall represent an average value of the units in the three countries. Each country will maintain this unit at its national laboratory in any way it may choose, *i.e.*, through pentane lamps, Carcel lamps, or incandescent lamp secondary standards, but by frequent intercomparisons among the various laboratories by means of incandescent lamps measured at each laboratory, the unit may be kept the same in the different countries.

It is probable that Germany would not be willing to change its unit by as much as 10 or 15 per cent., at least at present, but the ratio of the Hefner to the international candle could be determined and defined.

The adoption of a common unit of candle-power as distinguished from a standard lamp, suggests further a more complete differentiation of the functions of primary and working standards, and reduces the requirements demanded of each class of standards. On the one hand we should seek as a permanent custodian of the unit a primary standard, of which the only requirements would be a suitable colour, a suitable intensity, and exact reproducibility. It need not necessarily be simple, or inexpensive, or of great constancy over a long period of use. On the other hand, our working standards need no longer have the requisite reproducibility of a primary standard, but must remain constant after having been calibrated in terms of the unit. The seasoned incandescent lamp fulfils these requirements admirably for the photometry of electric lamps, but in the photometry of gas it is desirable to have flame standards that vary in intensity with changes in the atmosphere in the same direction and approximately to the same extent as the gas flame. It has usually been the custom heretofore to employ primary standards, such as the pentane lamp, in the photometry of gas, but is it not possible that a cheap and portable lamp might be found which would remain constant in intensity after having been calibrated, and which would be more convenient and more easily manipulated than the Harcourt 10 c.-p. pentane lamp?

In addition to the testing of secondary or working standards the Bureau undertakes to do a certain amount of commercial testing for various departments

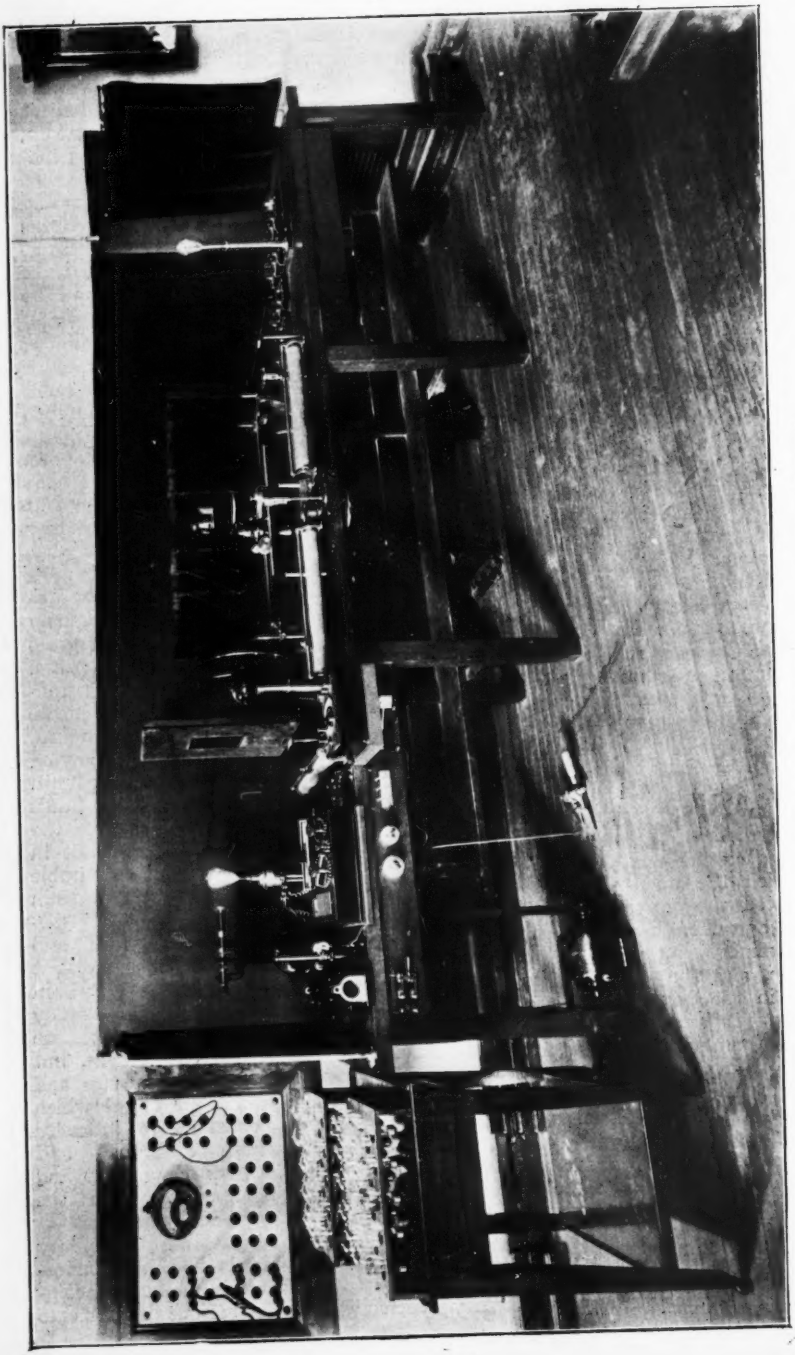


FIG. 5.—Photometrical Bench for Commercial Testing.

of the Government. and for private firms or individuals in cases of dispute, or where authoritative results are especially desired. It is prepared at all times to make special tests whenever these are practicable, to render assistance in the development of the proper methods of measuring luminous sources and illumination, and to aid as far as possible both the manufacturer and the consumer in preparing suitable specifications for the purchase of lamps.

It has been seen that the present equipment of the Bureau is designed for the most part for the testing of electric incandescent lamps. Although no work has been done thus far on arc lamps, and little work on the photometry of gas and oils, it is hoped in the course of time to broaden the work so that there will be facilities for measuring any kind of luminous sources. The photometry of incandescent lamps has been developed first because there seemed to be more demand for it.

Investigation.—Not the least important part of the work is the investigation of problems in photometry. This includes the study of standards (primary, secondary, and working), the development of accurate methods of photometric measurement, and the investigation of physical laws upon which the science of photometry depends. The scope of the work is therefore very broad, and the best results can be accomplished by maintaining a proper balance between investigation and testing. The one makes possible continual improvements in the other, and this in turn suggests fertile fields for further investigation.

The results of the investigations at the Bureau are published in the *Bulletin* of the Bureau of Standards, and also at times, usually in abstract form, in some of the technical journals. Each paper printed in the *Bulletin* is published separately in the form of a reprint, which may be obtained upon application. A list of the papers published up to the present time, containing in a few words a statement of the nature or results of each investigation, has recently been issued. The following list of papers in photometry has been copied from this source, the numbers referring to the order of publication in the *Bulletin*.

Papers on Photometry.—No. 12. On the 'Theory of the Matthews and the Russell-Léonard Photometers for the Measurement of Mean Spherical and Mean Hemispherical Intensities.' The accuracy of these instruments in measuring lamps with various simple polar distribution curves is investigated. The method is given for computing the best arrangement of any given number of mirrors to obtain relative values between lamps having different distribution curves.

No. 20. 'The Use of White Walls in a Photometric Laboratory.'—If proper black velvet screens are employed on a photometer bench the leakage of light into the photometer due to the diffuse reflection from white walls is shown to be so small as to be negligible.

No. 26. 'Talbot's Law as Applied to the Rotating Sectored Disc.'—The apparent intensity of a source, before which a sectored disc is rotating rapidly is found to be proportional to the total angular opening of the sectored disc for all angles between 288° and 10°.

No. 30. 'An Efficiency Meter for Electric Incandescent Lamps.'—By means of a variable resistance in series with the pressure circuit of a wattmeter and controlled by the position of the photometer screen, the wattmeter is made to indicate watts per candle directly.

No. 43. 'On the Determination of the Mean Horizontal Intensity of Incandescent Lamps by the Rotating Lamp Method.'—A study of the errors incident to this method, due (1) to the distortion of the filament on rotation, and (2) to the inability of the eye to estimate accurately a badly flickering illumination. By the use of a single stationary mirror accurate measurements of mean horizontal candle-power can be made even with badly flickering lamps.

No. 50. 'A Comparison of the Unit of Luminous Intensity of the United States with those of Germany, England, and France.'—A number of seasoned

incandescent lamps were carried abroad and measured in authoritative laboratories in the three countries named. The ratios of the units obtained through them are compared with the ratios generally accepted, and with those obtained in other recent investigations.

No. 51. 'Geometrical Theory of Radiating Surfaces with Discussion of Light Tubes.'—Assuming Lambert's cosine law and the inverse square law to apply to infinitesimal surfaces, the errors incident to applying them to finite surfaces are deduced for several simple cases. From a consideration of the case of an infinitely long, uniformly bright strip of finite width a theory of light tubes is developed.

No. 61. 'An Explanation of the Short Life of Frosted Lamps.'—The rapid decrease in candle-power of frosted lamps is due, at least partly, to the increased absorption of the carbon film deposited on the inner side of the bulb. Owing to the diffuse reflection at the frosted surface a relatively large part of the emitted light is compelled to traverse the absorbing carbon film three or more times before finally emerging. Results of confirmatory experiments are given.

No. 63. 'On the Determination of the Mean Horizontal Intensity of Incandescent Lamps.'—A continuation of a previous investigation on this subject (see Reprint No. 43). Other types of lamps are studied, and the methods and results of similar experiments by Uppenborn are discussed.

No. 72. 'A Comparative Study of Plain and Frosted Lamps.'—The various effects of frosting the bulbs of carbon filament incandescent lamps are studied as changes in (1) absorption, (2) distribution, and (3) life.

1. New lamps show an absorption of only 2 or 3 per cent., which increases rapidly as the lamp burns.—2. The distribution of light around frosted lamps depends on (*a*) the distribution curve of the bare lamps, and on (*b*) the shape of the bulb.—3. The theory advanced in a previous paper (see Reprint No. 61) to account for the short life of frosted lamps is further substantiated. Readings are given of the temperatures of the bulbs of plain and frosted lamps, both new and old.

An International Unit of Candle-Power.

(*Electrical World*, March 28th.)

At the convention at Boston last June a sub-committee of the Illuminating Engineering Society was formed to study the possibility of agreement upon an international unity of luminous intensity. Later the American Institution of Electrical Engineers, and the American Gas Institute, co-operated with this committee, and a final report was adopted in February, and is to come before the Illuminating Engineering Society very shortly.

The report advocates the establishment of one single unit of intensity throughout America, to be maintained by the Bureau of Standards, who will also issue sub-standards. The question of international agreement is also discussed, and it is suggested that in future a unit should be adopted, which shall be 2 per cent less than that now maintained at the Bureau of Standards at Washington. This change is advocated on the ground that such a unit is estimated to differ by less than 1 per cent. from the anticipated international standard.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

Further Remarks on the Injury to the Eyes caused by Ultra-Violet Light.

By Prof. Birch-Hirschfeld.
(*Zeitschr. für Augenheilkunde*, xx. vol. i.)

The author gives an account of five cases, closely examined during the course of two months, which illustrated the injurious action of the mercury-vapour light on the eye. Though the influence of such rays is serious, their recognition is hindered by the fact that such organic changes as are produced only give rise to slight subjective experiences, and therefore demand special methods of study.

1. Among these cases may be mentioned first the case of a student of twenty-five years of age who worked for the sessions with an 8–9 amp. Heraeus lamp, with unprotected eyes. He suffered repeatedly from sensations of watering, burning, and pressure on the eyes, and noticed, after being dazzled, a tendency to "see yellow," and obscuration of objects directly gazed at. One day, after working for a quarter of an hour in the immediate neighbourhood of the lamp, he suffered from severe electrical ophthalmia, and also subsequently discovered that his sense of colour was affected. In the right eye there appeared to be central and in the left paracentral relative scotoma, especially for the colours red and green.

2. A young man who had worked daily with unprotected eyes for several months at photographic work involving copying by means of the Uviol lamp. After several weeks he began to experience pain and burning sensations in both eyes, accompanied by a diminution in visual acuity; he also discovered that he could distinguish colours, especially red, yellow, and green less successfully than hitherto, and this was confirmed on examination.

3. Another worker in the same room, twenty-three years old, had experienced similar unpleasant sensations, and complained of diminished powers of distinguishing colours, particularly red and green tones. On examination, colour-disturbances in the field of view of both eyes were found to exist.

4. A third worker in the same room had copied by the aid of the Uviol light for about one year; in this case the left eye was proved to be insensitive to red and green.

5. This patient had carried out spectroscopic research with the Uviol lamp for several hours a day for several months. He, too, complained of pressure and burning sensations in the eye, and found difficulty in distinguishing colours. On examination a spot was found in the lower inner region of the field of view of the right eye, insensitive to red and green.

From the consideration of these cases Prof. Birch-Hirschfeld comes to the conclusion that the rays from the mercury-vapour lamp, besides causing trouble to the membranes at the back of the lens, may also give rise to injury by acting directly on the retina itself.

F. Schanz.

Arc Lamps for Photographic Work.

An interesting example of arc lamps intended for photographic purposes is exhibited at the electrical exhibit in the Machinery Hall at the Franco-British Exhibition.

In order to secure the predominance of the valuable ultra-violet radiation a long arc is desirable. In the present instance, therefore, a special type of flame carbons are employed and an arc no less than about 3½ inches in length is obtained.

The Meeting of the British Association.

The Annual Meeting of the British Association for the Advancement of Science is this year to be held in Dublin. The proceedings will open on Wednesday next, September 2nd, when an address will be delivered by Mr. Francis Darwin, F.R.S., the new President of the Association.

On the Injury that may be Caused to the Eye by Ultra-Violet Light.

By Dr. F. Schanz and Dr. K. Stockhausen.

(*Elektrotech. Zeitschr.*, Aug. 13, 1908.)

In addition to the account of the demonstration kindly sent us by Dr. Schanz and referred to on the last page, mention must be made of the paper by the same author recently read before the Verband Deutscher Elektrotechniker, and dealing with the same subject.

Dr. Schanz recapitulates the results quoted in the former article, and explains the considerations which render the use of a type of glass opaque to ultra-violet light desirable. For greater detail on these points we refer readers to our abstract in the January number of *The Illuminating Engineer* for the present year (p. 70). Briefly the author narrates how the researches of Widmark, Birch-Hirschfeld, Schulek, &c., have shown that the inflammation of the eyes following excessive exposure to arc-lights, &c., may be ascribed to ultra-violet rays, and that snow-blindness, and possibly also cataract, may be due to the same cause. Ultra-violet light must therefore be

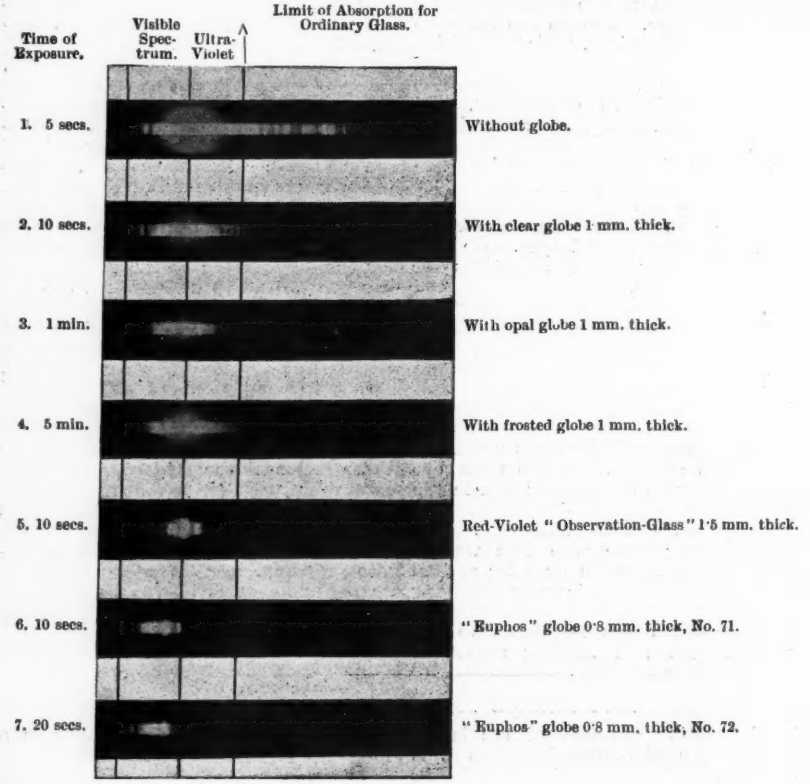


Fig. 1.—Electric Arc Lamp.

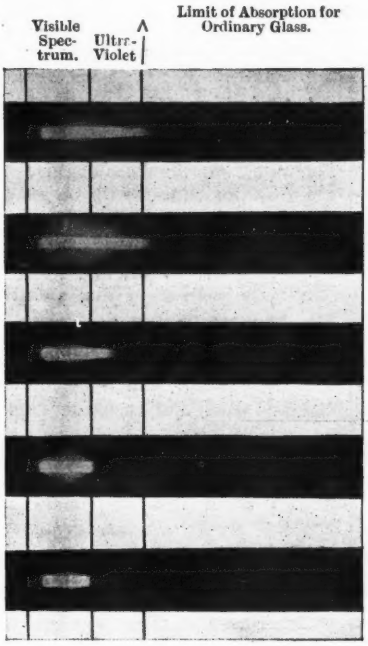


FIG. 2.—Nernst Lamp. Exposure 20 min.

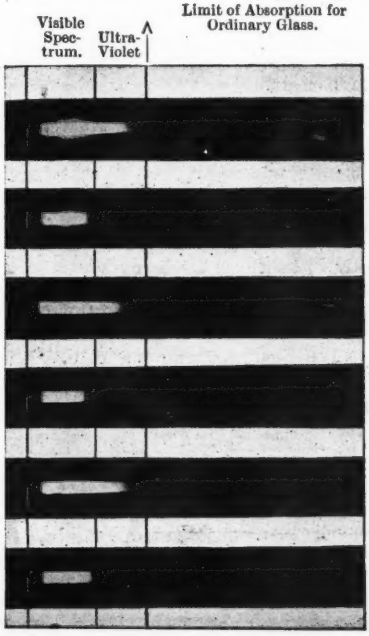


FIG. 3.—Metallic Filament Lamp. Time of Exposure 20 min.

regarded as harmful, and excluded from the light yielded by practical illuminants.

Yet the increasing temperature of incandescence of modern illuminants favours the production of such radiation, and the globes ordinarily in use have been shown by the author to transmit just those rays which he regards as most serious. Hence the value of the "Euphos" glass, which is opaque to this radiation.

Figs. 1, 2, and 3 furnish an interesting verification of the relative action of "Euphos" and ordinary glass in suppressing ultra-violet rays. Fig. 1 refers to photographs of the spectrum of an electric arc. It will be seen that the extent of the active spectrum in the case of the unscreened glass far exceeds that obtained when the various glasses are in use. Even the red "observation-glass," however, while shortening the spectrum considerably, does not entirely exclude the ultra-violet rays. The "Euphos" glass cuts off all ultra-violet light entirely, and the author also claims that it only absorbs about 2 to 3 per cent of the visible spectrum.

Figs 2 and 3 illustrate the effect of the "Euphos" glass in the case of various metallic filament lamps and the Nernst lamp respectively.

A Demonstration of the Effect of Ultra-Violet Rays in causing Reflex Action of the Eyelids, and Fluorescence of the Eye-Lens.

By Dr. F. Schanz.

(Demonstration before the Opthalmologische Gesellschaft of Heidelberg, 1908.)

Drs. Schanz and Stockhausen have previously referred to the fact that ordinary glass only absorbs the less penetrating ultra-violet rays, and mentioned their attempt to devise a special glass to absorb all ultra-violet rays completely (see *Illuminating Engineer*, Jan., 1908).

In the present instance the author allowed a stream of ultra-violet rays to fall upon the eye of an animal, when it was observed that the eyelids were sharply contracted together. It was also shown that the eye exhibited a bright green fluorescence under the action of these invisible rays.

It was shown further that neither of these effects was interfered with by interposing a sheet of ordinary glass 18 mm. in thickness, but, on the other hand, both immediately ceased when a strip of the special "Euphos" glass was used.

Drs. Schanz and Stockhausen have found that ordinary glass is effective in absorbing the very short wave length ultra-violet rays less than about 300 $\mu\mu$. But unlike "Euphos Glass," it allows rays between 300 and 400 $\mu\mu$ to pass, and Dr. Schanz's experiment, referred to above, is intended to show that it is just these latter rays that produce the most marked physiological effects, for they are able to penetrate through the eye-lens, and after bleaching the fluorescent material therein, act upon the retina itself. The disturbances of colour-vision recorded by Prof. Birch-Hirschfeld are caused under these conditions.

Need We Fear the Influence of the Ultra-Violet Rays of Modern Illuminants on the Eye?

By Dr. Voege.

(Abstracted from the *Elektrotechnische Zeitschrift*, Aug. 13, 1908.)

In this article Dr. Voege regards the question of the effect of ultra-violet light on the eye from an entirely different standpoint from that of Dr. Schanz. He remarks on the need for a comparison between the ultra-violet element in sunlight and artificial lights. Our eyes have been gradually developed and adapted to daylight, and we are therefore led to inquire why, if the intensity of ultra-violet light prove to be stronger in the case of natural daylight conditions, it should be considered necessary to use special absorbing glasses in the case of artificial lights.

It is an undoubted fact that exposure of the eye to sources of very great intrinsic brilliancy is injurious; but the author is doubtful whether this injury is to be ascribed solely to the ultra-violet element; on the other hand it may be admitted that the serious action of the ultra-violet rays from the mercury quartz lamp has been clearly demonstrated.

In order to compare the ultra-violet element in daylight and various artificial illuminants Dr. Voege has carried out the following experiment. He arranged to produce two exactly similarly shaped patches of light formed by daylight and the source of light under test, and altered the intensity of either until the brightness of the two patches appeared to the eye to be about the same. He then introduced a photographic plate, and obtained a negative of the bright image, thus comparing not the *brightness* but the chemically active ultra-violet intensity of the two patches of light. The plates used in these experiments were developed under exactly the same conditions, the exposure and strength of the developer being so selected that the blackness of the negative could be regarded as roughly proportional to the intensity. The appearance of the two patches of light *a* and *b*, divided by a vertical line, will be understood from Fig. 1.

Naturally a quartz lens, which transmits ultra-violet light, was used to produce the image. Provision was also made for the insertion of a piece of clear glass, 2 mm. thick, so as to cover the upper half of both patches of light; this, as will be seen in Fig. 1, divides the image horizontally. It was also possible to introduce a solution of Nitroso-dimethyl aniline in the course of the rays. This liquid has the property of strongly absorbing light of wave-lengths lying between 0·5 and 0·37 μ, but of transmitting light from the H and K line as far as about 0·2 μ.

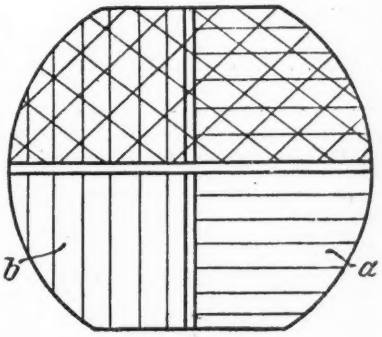
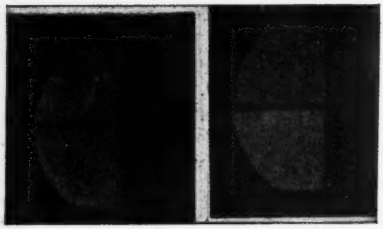


Fig. 1.

In Fig. 2 is shown a negative photograph illustrating the relative ultra-violet intensity of diffused daylight and light from the Nernst lamp, and an incandescent gaslight respectively. It will be seen that the right half of the image, corresponding to the Nernst lamp, is much the *lighter*. For a given physiological brightness, therefore, a surface illuminated by diffused daylight appears to be much richer in ultra-violet rays than one illuminated by the Nernst lamp. The same holds good for the incandescent mantle.

In the case of all the other artificial lights examined in this way, including

the incandescent gas light, miniature arc lamps, and carbon and metallic filaments, a result in the same direction was obtained—with two exceptions. These two exceptions are the quartz mercury-vapour lamp (without glass globe) and the Regina arc-lamp, both of which are known to be exceptionally adapted for photographic copying processes. Fig. 3

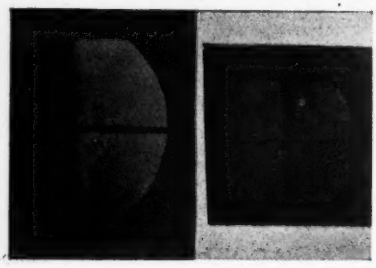


Incandescent Gas Burner. Nernst Lamp.

FIG. 2.

shows a result obtained with the former. Even in these cases the difference between daylight and the artificial light becomes but slight, if by daylight we understand light from the blue sky.

From the foregoing experiments, therefore, Dr. Voege concludes that in the case of all ordinary artificial sources of light, and as far as illuminated surfaces are



Compared with Diffused Daylight. Compared with blue sky.

FIG. 3.—Quartz mercury-vapour lamp.

concerned, the eye will be subjected to *less* ultra-violet energy when a given brightness is obtained. Naturally we may present to the eye an excess of ultra-violet energy if we are dealing with far too brightly illuminated surfaces. In the same way, possibly, injury to the eyes from ultra-violet light may be caused by looking straight at a brilliant unshaded artificial light. But, if we screen direct light from the eyes, and thus imitate natural daylight conditions, there would seem to be no reason to fear danger from reflected ultra-violet light from illuminated surfaces. Probably in many cases where fatigue is experienced the feeling may be attributed to the *want of uniformity* of the illumination.

We must, however, recognize that it is extremely difficult to avoid sometimes looking direct at artificial sources of light as usually arranged. On the other hand, we are also apt virtually to gaze directly at the sun, by receiving its rays direct from highly reflecting and sparkling surfaces (*e.g.*, mirrors, windows, placid water, &c.). Dr. Voege, therefore, next

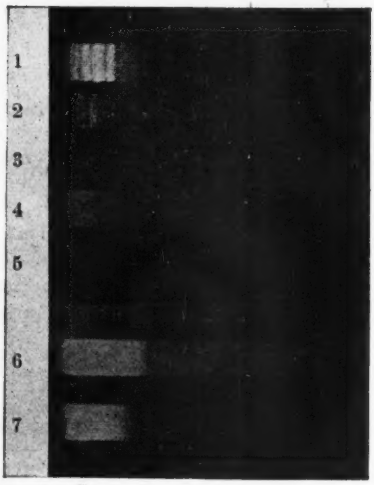


FIG. 4.

raises the question whether gazing for a short time at artificial sources of light may be expected to prove more injurious than receiving the rays of direct sunlight, and whether the ultra-violet element is stronger in the former case than in the latter. To test this point he arranged to take a spectro-photograph of a number of sources placed behind a narrow slit, all the photographs being developed, under exactly the same conditions, and the exposure being 5 seconds throughout.

The sunlight was imposed on the slit by reflection from a silvered mirror. The distances of the artificial lights were fixed at 40 centimetres in the case of glow-lamps and incandescent mantles, 60 centimetres in the case of small arc

lamps, and 100 centimetres in the case of the larger arc-lamps. This selection of distances is to some extent arbitrary, but it is hardly to be expected that any one who is not actually engaged in manipulating these lamps would look at them at shorter distances away than these.

The results of this experiment are shown in Fig. 4.

The numbers correspond to the following sources of light :—

1. Regina arc-lamp with no outer globe, 6 amps. 108 volts. Distance away 60 cms.

2. Carbone-Flame arc lamp (yellow light), 12 amps. 45 volts, 2,000 H.K., with opal globe. Distance away 100 cms.

3. Incandescent gas light, 75 H.K. Distance away 40 cms.

4. Nernst lamp with clear globe, 32 H.K. Distance away 40 cms.

5. Just-Wolfram lamp, 40 H.K. Distance away 40 cms.

6. Direct sunlight in July, 10 o'clock in the morning.

7. Sunlight transmitted through clear glass plate 2 mm. thick.

It can easily be seen that the spectrum of the direct sunlight extends far further into the ultra-violet than that of any of the artificial lights—even the Regina arc. Experiments with a somewhat wider slit and a 40-second exposure led to the same result, the spectrum of a white surface illuminated by direct sunlight again proving to be both longer and more intense than that of a flame arc-lamp.

On the whole, therefore, there seems no reason to believe that the light from a 2,000 H.K. flame arc at a distance of 2 metres from the eye exerts greater action upon it than a white surface illuminated by brilliant July sunshine, which our eye is often compelled to contemplate for 40 seconds or more without serious injury.

On the other hand, it is possible that the reason why a flame-arc appears to the eye so unpleasant at night may lie in the fact that the background is in this case relatively extremely dark in comparison with the source itself, the eye being mainly fatigued by the *contrast*. In the case of sunlight the contrast between a bright object and its illuminated surroundings is relatively trifling.

However this may be, the author fails to find any justification for the fear that artificial sources are likely to injure the eye through excess of ultra-violet energy over that in sunlight. On the contrary, the percentage of ultra-violet light is almost invariably greater in the latter case, and the use of special protective glasses in the case of artificial illuminants may be regarded as unnecessary.

Hygienic Regulations Affecting the Use of Petroleum for Illumination.

A RECENT number of the *Moniteur du Pétrole Roumain* contains an account of the methods of testing and generally supervising the use of petroleum for lighting purposes, suggested by a commission selected by the refiners of Roumania.

Petroleum destined for illuminating purposes is defined as the fractional distillate between 120° and 300° C. Liquid coming over near 110° C. must not occur in samples intended for purposes of illumination, while products between 110° and 130° C. must only form 5 per cent of the total distillate ; at least 80 per cent of this total distillate should consist of products distilling below 270° C. Other proposed regulations are that the specific gravity of the oil at 15° C. should not exceed 0·820, and that it should comply with specified conditions as regards colour, flash-point, &c.

Sanitary inspectors will undertake the testing of petroleum at the works, and there will also be qualified supervision of the conditions under which it is in actual use.

Regulations are also to be imposed governing the permissible location of refining works and the sanitary conditions under which the petroleum is treated ; the refuse-water of refineries must be disposed of in such a way as to avoid all possibility of contaminating surface or subterranean water in the neighbourhood.

White versus Black Letters in Printing.

In a recent number of *The Illuminating Engineer* of New York, Mr. A. J. Marshall made the suggestion that, from a physiological standpoint, it would be preferable for books and magazines to be printed in *white* upon a *black background* instead of in the ordinary way.

We give below a paragraph printed according to the system recommended by Mr. Marshall.

Naturally in such a case as this, the influence of custom is very strong, and one would ask for very distinct evidence of improvement in making such a radical change as that suggested. It is also open to question how far the mere fact of a certain amount of light continuously entering the eye (provided it is not above the upper limit of desirable brightness), can be regarded as responsible for eye-fatigue in reading.

In making this suggestion Mr. Marshall argues that the feeling of tiredness resulting from prolonged reading is partially due to the amount of light entering the eye. If, therefore, the plan of printing in *white* upon a black background were adopted, we ought to be able to see with equal distinctness, but the amount of light coming from the page to the eye would be very greatly reduced, as the letters on a printed page occupy but little room compared with the blank space. This, Mr. Marshall thinks, should render the operation of reading less tiring, while there is also a possibility that it may be psychologically preferable for the portion of the page, on which we desire to concentrate our attention, to be lighter than its background instead of darker.

Probably the continuous effort of accommodation of the eyes, and the actual mental effort of receiving and analyzing the impression conveyed by the printed matter, are much more influential factors, though, of course, *insufficient illumination* adds to the effort of reading, and *too bright* illumination dazzles the eyes of the reader.

As regards the purely optical side of the question there does not seem to be universal agreement among opticians. At present it is, of course, more usual for black type on a white ground to be used in tests, though some opticians have expressed themselves in favour of the reverse arrangement.

In an ordinary magazine, however, where more or less shiny paper is inevitable, another aspect of the question presents itself. Direct reflection from such paper is always inclined to be a nuisance, and it may safely be asserted that with white letters on a black ground the effects of such reflection would be much more noticeable.

The suggestion receives a more practical stamp than would otherwise be granted to it owing to the present commercial difficulties by which the paper trade appear to be faced in the United States. Almost all white paper is prepared from wood pulp, and the supply of this material is inclined to fail. The manufacture of such paper, in any case, makes serious demands on the existing forests of spruce and pine, which are alone serviceable for this purpose, and an agitation has recently been set on foot for the removal of the duty on foreign wood pulp. Moreover printing-ink seems to resist all bleaching actions so effectually as to render white paper that has once been used of no value for subsequent use *de novo*.

Paper manufacturers are therefore inclined to favour the suggestion that newspapers should be printed in white upon black paper in future. It seems to be agreed that black paper can be produced at a much cheaper rate, being capable of being manufactured out of all sorts of old stock and refuse, and the production of a serviceable white ink is also looked upon as feasible.

Effects of Light upon the Eye.

By Dr. H. H. Seabrook.

(From the *Transactions* of the Illuminating Engineering Society, February, 1908.)

Dr. Seabrook commences his paper with a brief summary of the nature and functions of the different portions of the eye, and then proceeds to consider the action of different varieties of light on the retina.

Experience has long ago shown how intense sunlight can injure, or even destroy, the retina, and the experiments of Brücke in 1845, and, subsequently, of Donders, Chardonnet, and Birsch-Hirschfield, have shown that such effects are mainly caused by the ultra-violet constituent in daylight. An exposure to powerful sources of ultra-violet energy for only half an hour may damage the cells of the retina, and with repeated exposures the lens of the eye may become permanently opaque. Of visible rays, those of *short* wave-length, the blue and the violet, are most influential. Disintegration of the pigment cells in the retina is a minimum in yellow light. At present there seems no reason to suppose that heat rays cause damage of this nature, though they may give rise to discomfort.

Dr. Seabrook next refers to the well-known trouble that may follow incautious exposure to arc-lights These severe effects are mainly due to concentration of energy on the eye. In practice the eye rests itself by constantly altering its position, and so receiving the bright image on different portions of the retina.

When, however, it is unable to do so, owing to the ubiquitous glare, exhaustion of the exposed portion of the retina is apt to occur. Modern illuminants are tending to grow continually more brilliant, and probably the old original kerosene burner is, from a physiological point of view, the safest of all.

Dr. Seabrook therefore recommends the use of amber-coloured diffusing shades, on the ground, firstly, that the intrinsic brilliancy of many illuminants must be diminished, and, secondly, that such yellow shades at once enable the eye to receive the variety of light to which it is best adapted and prevent the passage of objectionable rays of low wave-length.

Finally the author refers to the many disputed points and apparently contradictory conclusions reached by different workers in the subject of visual optics.

In discussion of the paper Dr. Louis Bell remarks that it was well known that *yellow* light is the most efficient in producing the sensation of light, and therefore also presumably most effectual in producing photo-chemical action in the retina; hence it seems a little surprising to learn that the most vigorous chemical action is caused by violet and ultra-violet energy.

It seems to be generally believed that the blue end of the spectrum is harmful; yet we must remember that natural light — daylight — contains a stronger violet and ultra-violet element than most artificial illuminants, and therefore it seems premature to decide that such light in moderate intensities is injurious. Dr. Bell also suggests that light of any colour, but especially monachromatic light, must tend to be injurious if it strikes the retina in excess. Very possibly even yellow light, the strong element in many flame arcs, for instance, might be injurious under certain conditions.

Prof. Clifford refers to the necessity for scientific consideration of the many disputed points referred to in the paper. Many people believe the mercury lamp to be restful to the eyes because it contained no red element. This, however, is in disagreement with the contentions of Dr. Seabrook. Prof. Clifford thinks that if the mercury lamp is really restful, this fact must be ascribed to some other cause than the absence of red rays. With reference to this point, Dr. Seabrook remarks that no doubt the low intrinsic brilliancy of the mercury lamp has much to do with the question.

Dr. A. E. Kenelly refers to the increase in the amount of light now considered

necessary in interiors. Dr. Seabrook, he remarks, commented on the effects of red and violet rays, but little information seems to be available as regards the action of the intermediate portion of the spectrum. Yet this may probably also be injurious if present in sufficient quantity. In examining the effect of different illuminants, therefore, we must distinguish between bad effects due to improper location of light-sources and bad effects due to peculiar colour. Many draughtsmen use the mercury lamp without being troubled in any way by the violet constituent in its spectrum, and Dr. Kenelly therefore doubts whether we are yet justified in believing these rays to be necessarily injurious. On the other hand, he is in agreement with the wisdom of avoiding prolonged exposure to light of any very unusual colour.

Mr. R. C. Ware remarks that in his experience strong red light does produce a feeling of positive discomfort. In this connexion Prof. Clifford contends that a distinction ought to be made between the purely physiological effect of breaking down cells in the retina, &c., and the psychological impression of discomfort arising from certain kinds of light.

Dr. Seabrook, in reply, points out how difficult it is to discriminate between these two effects, the retina of the eye being in reality an offshoot of the brain. It is hard to say, for instance, exactly why the bull is irritated by a red colour. As a matter of fact, however, investigators had come to the conclusion that red rays, though capable of causing discomfort, are not responsible for actual changes of tissue in the eye.

Dr. Seabrook also emphasizes the fact that sunlight itself is a very variable quantity, and must not be taken as a standard, under all conditions, of what light should be. Very bright sunshine may easily produce ill-effects, while the light in mountainous regions, which is specially rich in ultra-violet light, is still more apt to do so.

In further discussion of this paper some important points are raised by Mr. P. S. Millar. He, too, questions Dr. Seabrook's contention that chemical or short-wave rays are responsible for injury to the eyes, except when present in very exceptional quantities. He also draws attention to the fact that much of the eye-trouble at the present day arises from our using our eyes more, and testing them more severely. Much of the defective vision found among school-children is due to improper use of the eyes between the ages of seven and nine years. Such defects are therefore often not directly chargeable to the nature of modern methods of illumination.

Eyesight and Artificial Illumination.

By Dr. J. T. Krall.

(From the *Transactions* of the Illuminating Engineering Society, March, 1908.)

This paper bears upon the same aspects of the subject as that of Dr. Seabrook, abstracted above. Dr. Krall, while admitting the injurious influence of ultra-violet light in excess, thinks that the ill effects of modern sources depend mainly upon excessive brightness rather than anything peculiar in their radiation. He does not share the views of those who have freely condemned the electric light, believing that this kind of light, *wisely used*, is not only harmless, but one of the very best of modern illuminants. Nor does he agree with those who feel that the higher degree of illumination of surfaces attainable by the modern illuminants, as compared with that of the old candles, kerosene lamps, &c., is necessarily bad.

On the contrary the older lamps yielded too weak an illumination to enable us to carry out our present arduous work with comfort. It is, however, very essential that our brighter modern sources should be properly shaded. In the concluding portion of his paper the author gives a useful résumé of experimental work on the subject of ultra-violet light and its effects. One interesting instance of this effect is the prevalence of cataract among glass-blowers; this is attributed to the continual exposure to the ultra-violet rays given out by the glowing masses of clay and sand. Another is the effect of snow-blindness in high altitudes.

What is Light?

By P. G. Nutting.

An exceedingly interesting and valuable communication dealing with the physiological basis of light-perception by Mr. P. G. Nutting, of the Bureau of Standards, appears in *The Electrical World* for June 27th. We are still extremely ignorant on many points in connexion with the fundamental problems concerning the actual formation of the sensation of "light" in the eye, and might, indeed, echo the unconsciously humorous answer of the school boy, "Light, as I understand it, is very little understood."

Mr. P. G. Nutting's article deals mainly with the results of the complex nature of our methods of perceiving light and colour at low and high intensities. It is now

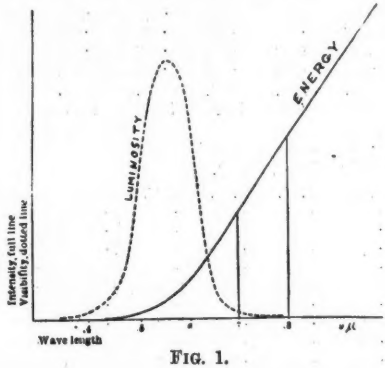


Fig. 1.

believed that at very low illuminations the eye acts in a profoundly different way from that characteristic of high illuminations, and makes use of an entirely different set of minute organs on the retina. At high illumination we utilize small organs known as "cones," at low illuminations a quite distinct variety known as "rods." Consequently the quality of light best adapted to certain purposes is very different in the two cases.

One question that goes to the very root of the theory of light production is the amount of energy the eye must receive in order to experience a certain sensation of brightness. Indirectly, suitable curves of energy radiation and luminosity of a certain illuminant enable us to calculate the mechanical equivalent of light.

Fig. 1, for instance, represents the energy and luminosity curves of a carbon filament glow-lamp as determined by Coblentz.

One evident uncertainty in calculating the mechanical equivalent of light according to the usual definition is that of deciding exactly what range of wave length we are going to term luminous. We can easily see from Fig. 1 what a great difference in the result would be occasioned by taking the upper limit as $0{\cdot}8\mu$ instead of $0{\cdot}7\mu$. The total light is hardly affected, but the energy is enormously increased.

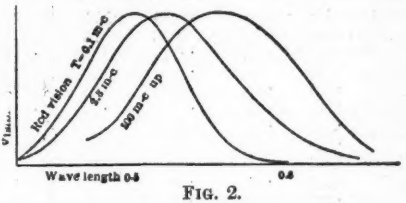


Fig. 2.

These problems, however, are enormously affected by the order of illumination employed—on whether we are working with weak light, and so depending on "rod-vision" or with a strong light, in which case we utilize "cone-vision." Intermediate sensations take place by the aid of both the rods and the cones in the eye. Thus Table I. gives some values of the distribution of luminosity in the spectrum, corresponding to

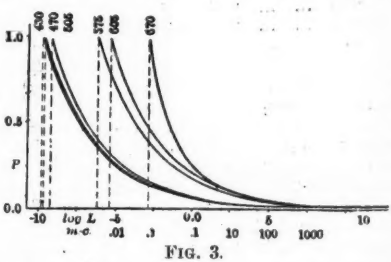


Fig. 3.

rod-vision, or cone-vision, or both combined.

Some curves derived from this table are shown in Fig. 2.

The general behaviour of different eyes, not known to be abnormal in any way, is broadly the same. Thus Koenig gives

the data shown in Table II. on rod-vision for ten different observers.

On the whole it appears that rod-vision is paramount for illuminations below 0·1 candle metres, while cone-vision is predominant for 100 candle-metres and upwards.

In Table III. are given some values of the mechanical equivalent in candles per watt for different wave lengths :—

identical for all colours. As the illumination is reduced the sensibility is reduced also, but at different rates in the case of the different colours, the red being naturally the first to die out, because the rods appear to be practically blind to this end of the spectrum.

In conclusion the author emphasizes the need for carefully preparing a complete tempered scale of light radiation,

Table I.

Rod and Cone Vision.—Visibility at Various Intensities.

Intensities.	·00024	·00225	·036	·575	2·30	9·22	36·9	147·6	590·4 m-c
Ratio to	Proceeding	9·38	16	16	4	4	4	4	4
λ= ·430	·047	·057	·076	·060	·063	·057	—	—	—
·450	·23	·21	·21	·20	·14	·10	·085	—	—
·470	·50	·46	·42	·42	·36	·19	·16	·13	—
·490	·85	·78	·75	·70	·63	·40	·28	·25	·24
·505	·99	·99	·98	·94	·88	·63	·50	·45	·40
·520	·97	·96	·94	·99	·97	·85	·72	·69	·67
·535	·75	·76	·76	·83	·98	·98	·91	·88	·87
·555	·36	·42	·47	·54	·83	·97	·99	·99	·99
·575	·12	·17	·20	·26	·58	·85	·97	·98	·98
·590	·045	·059	·095	·15	·42	·71	·88	·92	·92
·605	·015	·022	·044	·10	·28	·54	·71	·079	·79
·625	—	—	·022	·05	·17	·05	·42	·52	·54
·650	—	—	—	—	·057	·11	·15	·18	·23
·670	—	—	—	—	—	·038	·050	·055	·058
λ max	·511	·511	·511	·515	·529	·545	·560	·565	·565
Constant κ	461.	466.	445.	395.	254.	221.	214.	198.	197.
Vo/13 =	1·08	1·16	·94	·74	·31	·48	1·07	1·00	1·00

Table II.

Visibility at Low Intensity (Rod Vision).

Wave length.	A. B.	E. H.	F. D.	R. R.	E. B.	A. K.	A. H.	E. K.	F. H.	X. P.
·430	·015	·10	·038	·062	·064	·059	·047	·069	·31	·089
·450	·074	·30	·14	·25	·21	·21	·23	·23	·47	·01
·470	·27	·64	·31	·50	·47	·49	·50	·49	·74	58
·490	·57	·90	·58	·74	·80	·60	·86	·69	96	·84
·505	—	1·00	·85	1·00	1·00	1·00	1·00	1·00	1·00	·99
·520	1·00	·96	1·00	·85	·98	·99	·98	·87	·90	1.00
·535	·78	·77	·85	·64	·74	·77	·75	·66	·71	·81
·555	·45	·47	·49	·33	·41	·42	·36	·38	·44	·47
·575	·20	·20	·25	·12	·17	·17	·12	·14	·21	·13
·590	·085	·076	·15	·051	·067	·061	·045	·071	·10	—
·605	·035	—	·09	·022	·026	·022	·015	·024	·048	—
λ max	·518	·507	·521	·504	·512	·511	·511	·506	·502	·514

Table III.

Wave length.	Watt cm².	Meter-candles.	Meter-candles, watt/cm².	Candles, watt.
·620	·000162	64	390,000	3·1
·566	·000042	64	1,520,000	12·1
·566	·000036	61	1,700,000	13·5
·595	·000123	182	1,480,000	11·8

Another factor which varies with the illumination, and has been exhaustively studied by Koenig and Brodhun, is the photometric sensibility, the reciprocal of which is the minimum charge of illumination that the eye is capable of detecting at different intensities. Their results are shown in Fig. 3. Briefly it appears again that at high illuminations the photometric sensibility is practically

including all wave lengths and all intensities. Though the broad lines on which such an investigation should proceed are now mapped out, many requisite data are missing. Naturally any attempt to decide on a primary standard of light must include a consideration of all these physiological phenomena.

CORRESPONDENCE.

The City Lighting.

SIR,—It has afforded me great pleasure to read Mr. Voysey's report on the public lighting of the City of London, published in the July issue of *The Illuminating Engineer*. The thoroughly practical investigation that Mr. Voysey conducted and the excellent manner in which he has plotted the results reduce to a small compass, that is readily observed and grasped, information that must have taken a very long time, and a vast expenditure of patience to collect. One regrets that such a systematic examination should be confined to the comparatively narrow limits of the City; in the many miles of streets comprising greater London all sorts and conditions of public lighting are to be found, where the local authority is also the electric lighting authority I doubt whether any lighting inspector exists, or if he does he is not allowed to act, for many of the street arc lamps are run much below normal candle-power, are frequently very badly placed, and not sufficiently well adjusted to do public service, whilst the globes are usually dirty and sometimes broken. The incandescent gas light has now made people accustomed to a big white light, so that whereas fifteen years ago electrical engineers were afraid of blinding people with too strong a light, the gas people have now broken the ice, and it is no longer necessary to hide an arc light inside of a thick opal globe on which dirt has been allowed to accumulate unnoticed.

In regard to the central suspension of street arc lamps, some experiments, which I helped to carry out whilst acting as assistant engineer to the Italian Edison Company in Milan twenty years ago, proved conclusively that equal illumination of the streets could be obtained with thirty per cent less lamps placed centrally than if placed along the kerb lines, and those who know Milan will remember that all the main thoroughfares are lighted in that way. In this country there has always been the difficulty of obtaining the sanction of property owners for the attachment of supports to the fronts of buildings for the purpose of carrying the lamps, in a few places—as in Oxford Street—central standards have been fixed, but it is questionable whether the additional lighting efficiency secured by their central position is not more than counter balanced by the consequent reduction by perhaps fifty per cent of the amount of traffic which can now pass along the road; in the City the accumulated wisdom of age has secured the privilege of compulsory attachment to buildings for public lighting purposes, and it is a most valuable asset in connexion with the scheme.

I am, &c.,

CHAS. A. BAKER.

Whitehall Club, S.W.

The Testing of Gas Burners.

To the Editor of 'The Illuminating Engineer.'

August 7th.

SIR,—I have read with great interest, in your last issue, Prof. Morris's article on gas burner tests, a subject which I find engrossing. I note without surprise the great increase of efficiency obtained with the Keith burner when it was removed to another gas supply.

The fact is that burners in general are not only sensitive to change of pressure and calorific value, but also even more so to changes in the

composition of the gas, whether entirely coal gas or partially water gas. At present, if good results are to be obtained, burners must be run on the right pressure, with gas of the right calorific value, and with gas of the right composition, according to the design of the burner, and changing over to any other gas supply may reduce the efficiency by one-half. Comparative tests between burner and burner are quite misleading unless the burners are tested on the supply on which they are to be used, and the tests must then be only considered as applicable to that particular supply.

Truly the position of the gas-burner manufacturer is not a happy one. If the efficiency of gas lighting is to be raised to something like the claims of its partisans, steps must be taken to standardize the conditions. Burners can then be marked for use under certain specified conditions, and the consumer discouraged from using burners not suitable for his particular supply.

The first thing to take in hand will undoubtedly be the pressure. The Gas Light and Coke Co. supply me with gas varying in pressure from 2 to nearly 4 inches, measured at the meter, and this is one of the most up-to-date companies in existence.

When the supply pressure is standardized and maintained constant by means of governors fixed with the meters, it will then be time to attend to the internal piping. Why should not the amount of gas passing through a pipe in a house be subject to rules such as electric light installations have to conform to?

After the pressure has been standardized, attention must be turned to calorific value and composition of a gas. These cannot be entirely standardized, as the best sort of gas to manufacture depends so much upon local conditions, but burners might be designed and marked for various sorts of gas just as electric lamps are marked for various voltages.

When all this is done, the burner with a gas regulator and air-regulator, bad enough singly and abominable when combined in the same burner, and which the consumer never properly adjusts, will become a thing of the past.

I note that Prof. Morris finds in one instance that the increase of pressure of 1 per cent is accompanied by an increase of light of ½ per cent only. On looking up various tests carried out on domestic burners I find that I have obtained various values ranging from 0·5 per cent to 3·60 per cent increase for each increase of 1 per cent in pressure from 2 inches.

Yours faithfully,

LANCELOT W. WILD.

Meeting of Lamp Testers.

A MEETING of all the lamp inspectors in the employ of the electrical testing laboratories was held in New York on July 6th, 7th, and 8th, inclusive. The following papers were presented and discussed:—

'Visual Inspections of Electric Lamps,' by C. E. Currier.
'The Best Procedure in Lamp Inspection,' by C. H. Stephens.
'The Selection of Life Test Samples,' by H. E. Allen.
'The Effect of Varying Test Quantity upon Rejections,' by W. F. Teneyck.
'"Bugs" in Photometry,' by E. L. Peck.
'Lamp Inspections at Purchasing Companies' Storehouses,' by W. J. Bray.
'The Criterion of Lamp Value,' by A. W. Minty.
'The Value of Laboratory Tests,' by W. H. Robinson.
'The Functions of a Lamp Inspector,' by Geo. H. St. John.
'The Responsibilities of a Lamp Inspector,' by L. J. Lewinson.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

AMONG the contributions of the month dealing specifically with ILLUMINATING ENGINEERING may be mentioned that of **J. R. Cravath** (*Electrical World*, N.Y., Aug. 1st). The author points out the importance of this subject to the electrical contractor, and makes a number of suggestions with regard to the functions of shades and reflectors. It is not easy to form a really satisfactory definition of the "efficiency of illumination," though the percentage of the total light generated that is cast directly upon a plane 30 in. from the floor is sometimes so defined. This, however, leaves out of account the desire of the consumer to spend a certain amount of light on his walls and ceiling.

It is, in fact, essential to use some light in this way; otherwise the contrast between the brightly illuminated table and its sombre surroundings becomes unpleasant. It is for these reasons that opaque prismatic reflectors are preferable to enamelled opaque ones. By suitably designing the former we can arrange for any desired percentage in the light to pass upwards. Mr. Cravath remarks that it is usually advisable for 25 to 35 per cent of the light to be used in this way.

E. L. Elliott writes upon the LIMITS OF ART IN FIXTURE DESIGN. Such design must be a perpetual compromise between the æsthetic and utilitarian considerations, but a want of knowledge of the principles of illumination often leads to the design of globes which do not distribute the light satisfactorily, even though a trifling alteration in design might accomplish this end without impairing their artistic merits.

Among common faults in such lamps, Mr. Elliott mentions the use of coloured glasses which absorb a great deal of light without distributing it effectually.

In many cases, indeed, only a narrow circle of light is produced, and all the surrounding region is left in darkness.

Perrot (*T.I.E.S.*, June) discusses the principles of CHURCH LIGHTING, illustrating his contentions with some interesting illustrations. Here, again, we find a recognition of the necessity for satisfying both the æsthetic and practical conditions. The difficulty is intensified in ritualistic churches on account of the symbolic significance of decorations employed. Even here, however, modern sources of light have found useful application to meet the requirements of special occasions, judging from the photograph of some Christmas decorations.

In the discussion of this paper there seemed to be a general recognition of the desire for a subdued illumination, and inverted systems of lighting were mentioned with approval.

Marshall and Rolph (*Illuminating Engineer*, N.Y., July) contribute an article on the ARTIFICIAL LIGHTING OF SCHOOL-ROOMS. The article is illustrated by photographs showing the position of the desks and the various lights used, and also diagrams indicating the intensity and distribution of light.

It is interesting to find that in this case the authors recommend the use of enamelled opaque reflectors, on the ground that a more perfect diffusion can be obtained in this way.

A recent number of *The Electrician* contains a well illustrated article, describing a novel system of inverted lighting by Osram lamps, in use at the Inns of Court Hotel, Holborn.

E. W. Weinbeer (*Elek. Anz.*, Aug. 2) describes some graphical constructions for determining the shape of reflectors designed to provide a uniform ground-illumination.

A recent number of the *Elektrotechnische Zeitschrift* contains the complete paper by **Drs. Schanz and Stockhausen** on the EFFECT OF THE ULTRA-VIOLET RAYS IN ARTIFICIAL ILLUMINANTS ON THE EYES, and also an article by **Dr. Voege** on the same subject.

Schanz and Stockhausen take the view that ultra-violet rays, in excess, are actually known to produce serious injury to the eyes, and mention a number of cases recorded by Prof. Birch-Hirschfeld where this has been the case. Dr. Schanz has also demonstrated their effect on the eyes of an animal (*Z. f. B.*,

Aug. 20), in causing contraction of the eyelids and fluorescence of the lens.

The authors therefore propose to surround artificial illuminants with a special variety of "Euphos" glass which *completely* absorbs ultra-violet energy. Some spectro-photographs are given which show that ordinary glass fails to absorb these rays completely but that "Euphos" glass does, and that without absorbing more than 2 to 3 per cent of the visible spectrum.

Dr. Voege, on the other hand, describes a series of experiments intended to show that, for a given brightness, daylight is richer in ultra-violet rays than all the artificial illuminants examined with the exception of the Quartz mercury-vapour lamp and the Regina-arc lamp; and these are specially designed with a view to the production of these rays. Therefore he sees no reason why absorbing glasses should be considered necessary in the case of artificial sources and not in the case of daylight. This matter has given rise to some very lively discussion before the German Institution of Engineers, and further details may be expected shortly.

Among other articles of interest we may mention that by **Herlt** on the progress of illumination in Turkey. Orientals, he remarks, are content with extremely dim daylight-illumination in their interiors, and also seem to dislike, or at least to see no reason for, any but the feeblest artificial lights.

Hence we find that in Turkey the oil-lamp reigns supreme, and difficulties are put in the way of gas and electric lighting, which have as yet made but small progress. Acetylene is tabood as too dangerous.

Among contributions of a more photometrical nature, attention may be drawn to the discussion of the recent paper by **Dr. Steinmetz** on a NEW PRIMARY STANDARD OF LIGHT. The suggestion is that such a standard should be formed by the mixture of three monochromatic lights in a given proportion. It also seems to be assumed that it would be possible to define the standard light by merely specifying the amount of energy of each constituent.

In the discussion the chief difficulty suggested seemed to lie in the actual measurement of the energy of a narrow band of light. Apart from this, one could suppose that the usual physiological difficulties are only postponed, and not conquered; and it also seems undesirable to select a primary standard differing so markedly in spectral composition from ordinary daylight.

In the course of the discussion, an interesting declaration is attributed to Dr. Steinmetz, to the effect that he believes the mechanical equivalent of light to be much higher than is commonly supposed to be, in fact, as high as 50 candles per watt.

Fery (*Jour. de Physique*, Aug.) describes an attempt to form a direct-reading photometer which seems to have been carried further than is usually the lot of such instruments. A thermo-couple arrangement, on similar lines to the Radio-micrometer, is utilized; the radiation, however, passes through a graded screen of copper acetate solution. This is said to absorb the energy in the different regions of the spectrum in such proportions as to produce what is virtually the same curve of sensitiveness as that of the eye.

As an example of the correctness of the instrument the author gives some measurements of the efficiencies of various glow-lamps which approximate to the values usually accepted.

ELECTRIC LIGHTING.

The prospects of the metallic filament lamps, as usual, receive attention. Several papers have been read on the subject in the United States, and it seems to be generally accepted that there is no danger of their causing inconvenience to the supply companies.

It is, indeed, generally recognized that the supply companies, who are themselves controlling the sale of lamps to contractors, should take pains to let them understand both the possibilities and present disadvantages of the tungsten lamps. Much interest has been aroused by the issue of a 100 volt 20 to 25 watt tungsten lamp in the United States.

The articles by **Duschnitz and Schmidt** in the *Elek. Anzeiger* are continued in more recent numbers of this journal. Mention may also be made of a general article (*Elek. Anz.*, Aug. 16) reviewing in an up-to-date manner the PROGRESS OF ELECTRICAL ILLUMINANTS. The writer refers to the advantage of long-burning hours enjoyed by the enclosed carbon arc-lamp, the limit of which, however, he fixes at 300 hours.

He also gives some interesting particulars of a new form of Blondel flame-arc, with upright carbons, which will burn for twenty-four hours without recarboning, and can be run three in series on 110 volts.

The recent papers by **Wedding** and **Remane**, mentioned in the last review, have now been reprinted in full. Wed-

ding's paper contains the results of a very RECENT SERIES OF TESTS ON METALLIZED TANTALUM, AND WOLFRAM LAMPS. In contradiction of Remané's previous suggestions, he believes that the future of the metallic filament lamps will lie in the production of one for 220 volts and 16 c.-p. upwards. He also hints that in future the battle between gas and electricity is likely to be fought out mainly on cost of maintenance and general convenience, rather than cost of energy.

Remane's more recent paper contains a series of tables and diagrams designed to prove the superiority of HIGH CANDLE-POWER OSRAM LAMPS—which are now made to yield as much as 400 H.K.—over the SMALLER ARC LAMPS. Much discussion turned on the possibility of running such lamps successfully, two in series on 220 volts, and their capacity to withstand shock and overrunning. Remané cites a case in which a railway collision occurred, and practically the only things left intact afterwards were the osram lamps in the carriages!

B. Walter (*E. T. Z.*, July 16) criticizes the results recently obtained by Hirschauer with regard to the EFFECT OF CHANGE OF PRESSURE ON NERNST LAMPS. He described some tests on the subject, and finds that the result depends very greatly indeed on the iron resistance in series with the glower. On the average a 5 per cent change in P.D. produced a 12 per cent change in candle-power. Cases were met with, however, in which changes of 30·8 per cent and 45·7 per cent occurred.

Freeman (*Elec. World*, N.Y., Aug. 15) describes some extremely interesting experiments on the "overshooting" of tungsten lamps. He obtains simultaneously records of the intensity of the light yielded by carbon and metallic filament lamps and oscillographic tracings of the growth of current when the lamp is switched on.

The results show very clearly the difference in the behaviour of the current in the two cases, an "overshooting" only occurring in the case of the metallic lamp. Another interesting illustration exhibits pulsations in the light from a tungsten lamp on an alternating P.D. taking place simultaneously with the reversal of current.

MISCELLANEOUS.

Under this heading particulars may be given of one or two papers which, while not bearing very directly on electric lighting or problems of illumination, are yet of interest.

W. Coblentz (*Bull. Bureau of Standards*, May) and **A. Pfluger** (*Ann. der Physik.*, No. 9, 1908) have carried out some interesting researches on the character of the RADIATION FROM THE NERNST FILAMENT and the QUARTZ MERCURY-VAPOUR LAMP respectively.

Coblentz, among other researches, traces the alterations in the distribution of energy in the spectrum of the Nernst filament with rise of temperature, and shows that they are not in accordance with the black body law. In general there appear to be a series of bands at low temperatures which eventually coalesce and the filament shows marked evidence of selective radiation. **Pfluger's** experiments are likewise designed to study the distribution of energy in the spectrum of the mercury lamp, and he seeks to deduce some general law governing its radiation.

W. S. Grippenberg (*Phys. Zeit.*) describes a new method of forming light-sensitive selenium cells by the sublimation of selenium vapour upon a suitable non-conducting surface.

GAS-LIGHTING, &c.

Few contributions to the subject of gas-lighting dealing specifically with problems of illumination have appeared during the last month.

Of considerable importance, however, is the decision on the part of the **Edinburgh and Leith Gas Commissioners** to REDUCE THE CANDLE-POWER OF ILLUMINATING GAS FROM 20 TO 14. Very recently the candle-power of the gas supplied was as high as 25, but it was stated in the evidence that only about 15 per cent of the gas supplied is used for flat-flame burners, so that illuminating, as compared with calorific value, must be considered relatively of little importance.

Another matter of some interest in the gas world is the high figure for the UNACCOUNTED-FOR GAS, occurring in the report of the Gas Light and Coke Co. The increase amounts to no less than 122 million, making the unaccounted-for gas for the present year 7½ per cent of the total gas generated.

In reality it need not, of course, be assumed that all this gas is necessarily lost, and there are various items of uncertainty affecting its measurement at the works and the meters; but still the exceptional increase for the present year is causing some concern.

A novel and interesting METHOD OF INCANDESCENT GAS-LIGHTING is being exhibited at the Franco-British Exhibition by the **Buisson-Hella Co.**, and is described in a recent number of the *Journal of Gaslighting*. The "bush-

light"—it can hardly be termed a mantle—consists of a cluster of rods of 0·8 mm. in diameter and 25 to 30 mm. in length, which are made of rare earths and incandesce in the usual way.

Though, of course, brittle to the touch, they are said to withstand vibrations extremely well and to resemble mantles of the ordinary variety in efficiency. The filaments can be twisted in the plastic state into any desired shape; it is also stated that the colour of the light yielded by them can be controlled by altering their chemical conposition.

Lux (*Z. f. B.*, Aug. 14) gives the results of some tests on several "BENOID" BENZINE AIR burners. The figures vary from 1·2 to about 1·5 litres per H.K.-hour, according to the type of burner, and the practical manipulation of the gas-generating apparatus is stated to have given satisfaction.

Though the calorific value of the gas (3,300 g. cal. per litre) is somewhat less than that of ordinary illuminating gas, a higher flame-temperature is attained than in an ordinary gas-burner, and a whiter coloured light, as was proved by spectroscopic study. The radiant efficiency is likewise higher, presumably on account of this higher temperature.

Meyer-Liegnitz (*J. f. G.*, Aug. 14), describes a new form of MECHANICAL MANTLE TESTER, which serves to compare the resisting power of mantles to vibration.

The RELATIVE MERITS OF COMPRESSED-AIR AND COMPRESSED-GAS INSTALLATIONS are again under discussion. On the whole it is contended that the former system is preferable, though it may not be desirable to remove existing high-pressure gas systems in actual operation.

The necessity for a special meter for high-pressure gas is cited as a drawback, and the effect of a leak is stated to be injurious to the trees or shrubs used to line the streets.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Cravath, J. R. Illuminating Engineering (*Elec. World*, N.Y., August, 1908).
Devaux, E. Observations sur la communication de MM. Broca et Laporte (Bull. Soc. Int. des Electricians, July, 1908).
Elliott E. L. The Limitations of Art in Fixture Design (*Illuminating Engineer*, N.Y., July).
Féry, Ch. Photomètre à Lecture Directe (*Jour. de Physique*, Aug.).
Gaster (L.) Illumination and Hygiene (*Jour. of the Society of Arts*, Aug. 21).
Hammer (W. J.), Ein neues Selenphotometer (abstr. *Elek. Anz.*, Aug. 2).
Herlt, G. Das Beleuchtungswesen in Türkei (*J. f. G.* Aug. 1).
Johnstone, G. A. A New Source of Illumination (*Elec. World*, N.Y., Aug. 15).
Lerche. Der Stand des Beleuchtungstechnik und die Beleuchtung im Post u. Telegraphbetriebe (*Archiv. f. Post u. Teleg.*, 1908, Nos. 8 and 9; *Ann. der Elektrot.*, No. 8, 1908).
Loring, G. The Electrical Contractor's Opportunities in the Illuminating Field (*Elec. World*, N.Y., and *Elec. Rev.*, N.Y., July 25).
Marshall, A. J., and Rolph, T. W. Artificial Lighting of Schoolrooms (*Illuminating Engineer*, N.Y., July).
"Multipolaris." Lamp-posts (*Illuminating Engineer*, N.Y., July).
Perrot, E. S. Church Lighting (*T. I. E. E.*, June).
Schanz and Stockhausen, K. Die Schadigung des Auges durch Einwirkung des Ultravioletten Lichtes (*E. T. Z.*, Aug. 13).
Schanz, F. Demonstration des durch ultravioletten Strahlen zu erzeugenden Lidschluss-Reflexes und der durch diese Strahlen veranlassten Fluorescenz der Linse (*Z. f. B.*, Aug. 20).
Voege. Ist durch das ultraviolette Licht der modernen kunstlichen Lichtquellen eine Schädigung des Auges zu befurchten? (*E. T. Z.*, Aug. 13).
Weinbeer, E. W. Die graphische Konstruktion der Reflektoren (*Elek. Anz.*, Aug. 2).
The Electric Lighting of the Union Station, Washington, U.S.A. (*Elec. World*, and *Elec. Rev.* N.Y., Aug. 1).
Discussion of Paper by Steinmetz on 'A Primary Standard of Light' (*Elec. World*, N.Y., Aug. 15).
Reflected Lighting with metallic filament lamps (*Electrician*, Aug. 14).

GASLIGHTING, ETC.

Celle, Fernzündung der Strassenlaternen (*J. f. G.*, Aug. 8).
Grey, J. E. The Hygiene of Burning Gas (*Progressive Age*, Aug. 1, *Am. Gaslight Jour.*, Aug. 3).
König. Die neuesten Fortschritte im Gasfach (*J. f. G.*, Aug. 14).
Lux, H. Untersuchung eines Benoid gas apparatus (*Z. f. B.*, July 30 and Aug. 10).
Meyer-Liegnitz. Glühkörper-Festigkeitsprüfer (*J. f. G.*, Aug. 14).
Edinburgh and Leith Commissioners' Provisional Order, to reduce candle-power of gas to 14 (*G. W.*, Aug. 1, *J. G. L.*, July 28).
Public Lighting by High Pressure Gas in Berlin (*J. G. L.*, July 28).
The Mitchelite Petrol-Air Gas Apparatus (*J. G. L.*, July 28).
The "Hella Bushlight," rod filaments for incandescent gaslighting (*J. G. L.*, Aug. 4).
Pressgas oder Luftgas (*J. f. G.*, July 25; see also *J. G. L.*, Aug. 25).
The Illumination of Political Banners (*Am. Gaslight Journal*, Aug. 3).

MISCELLANEOUS.

Coblentz, W. W. Selective Radiation of the Nernst Glower (Bull. Bureau of Standards, U.S., May).
Gripenberg, W. S. Ueber die Anwendung von Selendampf zur Herstellung von Lichtempfindlichen Zellen (*Phys. Zeitschr.*, Aug. 1).
Pflüger, A. Die Gesetze der Temparaturstrahlung und die Intensitätsverteilung im Spektrum der Quecksilberlampe (*Ann. der Physik*, No. 9).

ELECTRIC LIGHTING.

Duschnitz, B. Metallische Leuchtfäden in der Fabrikation und in der Praxis (*Elek. Anz.*, Aug. 9, Aug. 20).
Editorial. The City Lighting (*Elec. Engineer*, Aug. 7).
The Problem of the Small Consumer (*Elec. Rev.*, July 31).
The 25-Watt Tungsten Lamp (*Elec. World*, July 25 and Aug. 1).
Ennsbrunner, A. Die Quarzlampe (*Elek. u. Maschinelle Betriebe*, 1908, Nos. 6 and 7; *Ann. der Elektrot.*, No. 7, 1908).
Freeman, J. S. Conclusive Evidence of the "Overshooting" of Tungsten Lamps and other interesting Phenomena (*Elec. World*, N.Y., Aug. 15).
Freeman, W. W. The Status and Commercial Possibilities of High Efficiency Lamps (*Elec. Engineering*, Aug. 20, abstract).
J. W. B. Daylight Saving: Influence of the Proposed Changes on the Electric Lighting Industry (*Elec. Engineer.*, Aug. 21).
Ladoff, J. Recent Progress in the Voltaic Arc (*Illuminating Engineer*, New York, July).
Long, F. W. Electric Street-Lighting (*Jour. Inst. of E. E.*, London, Aug., 1908).
Remané, F. Vergleich von Betriebskosten kleiner Bogenlampen und hochkerziger Osramlampen, complete paper and discussion (*E. T. Z.*, Aug. 20).
Seelman, M. S. Introducing the Tungsten Lamp (letter, *Elec. World*, N.Y., July 25).
Schmidt, J. Ueber elektrische Strassenbeleuchtung deren Systeme und ihre Rationellität, (*Elek. Anz.*, July 26, Aug. 2, 6, and 23).
Wagoner, W. W. Street-Lighting with Metallic Filament Lamps in Series (*Elec. Engineering*, Aug. 20, abstract).
Walter, B. Einfluss von Spannungsschwankungen auf die Helligkeit von Nernstlampen (*E. T. Z.* July 16).
Wedding, W. Neuere Errungenschaften in der elektrischen Beleuchtung (complete paper, *E. T. Z.*, July 30).
Denver Convention Illumination (*Elec. World*, N.Y., July 25; *Progr. Age*, Aug. 1).
Electric Light Display at Seattle (*Elec. World*, N.Y., Aug. 15).
The Lighting of Cotton Mills (*Elec. World*, N.Y., Aug. 15).
Die elektrische Beleuchtung und ihre Entwicklung (*Elek. Anz.*, Aug. 16).
Lampe à Filament Metallique "Phillips" (*L'Electricien*, Aug. 8).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
Elektrot. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society.*

The International Electrical Congress at Marseilles.

THE congress is to be held at Marseilles on September 14th to 20th of this year, and will deal with many general, technical, commercial, and administrative proplems.

An interesting programme of papers has been issued, among which we note the following two papers in the fourth section which are of special interest from the standpoint of illuminating engineering:—

M. A. BLONDEL — Rapport sur les procédés d'éclairage électrique.

M. F. LAPORTE — Rapport sur les spécifications et la photométrie des lampes électrique.

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

14,851. Metallic filaments for incandescent lamps. July 13. C. Trenzen and F. R. Pope, 322, High Holborn, London.

14,852. Titanium filaments for incandescent lamps. July 13. C. Trenzen and F. R. Pope, 322, High Holborn, London.

14,853. Metallic filaments for incandescent lamps. July 13. C. Trenzen and F. R. Pope, 322, High Holborn, London.

14,867. Incandescent lamp filaments. July 13. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)

14,910. Protective covers for glow lamps (C.S.). July 14. (I.C. June 1, 1908, Germany). Siemens-Schuckertwerke G. m. b. H., Queen Anne's Chambers, Broadway, Westminster.

14,942. Tungsten filaments for incandescent lamps. July 14. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Buildings, Norfolk Street, Strand. (From Westinghouse Metallfaden Glühlampen Fabrik G. m. b. H., Austria.)

14,961. }
14,962. } Metallic filaments for incandescent lamps. July 14. W. Majert, 4, South Street, Finsbury,
14,963. } London.

14,982. Arc lamp, with inclined carbons (C.S.). July 15. Veritys, Ltd., and F. S. Worsley, 11, Burlington Chambers, New Street, Birmingham.

15,030. Incandescent lamps. July 15. F. Wilkins, 6, Lord Street, Liverpool.

15,057. Metallic filament lamps. July 15. W. Majert, 4, South Street, Finsbury, London.

15,079. Decarbonizing metallic filaments (C.S.). July 16. H. Aron and A. Geiger, 77, Colmore Row, Birmingham.

15,080. Metallic filaments for incandescent lamps (C.S.). July 16. H. Aron and A. Geiger, 77, Colmore Road, Birmingham.

15,116. Arc Lamps. July 16. L. Shaw, Clun House, Surrey Street, London.

15,328. Soldering metallic filaments to their electrodes (C.S.). July 20. S. Marietti, 72, Cannon Street, London. (Addition to 14,483/08).

15,346. Mounting and feeding carbons in arc lamps. July 20. S. C. Mount and Beck Flame Lamp, Ltd., 27, Chancery Lane, London.

15,979. Lamps. July 28. Van Raden & Co., Ltd., and M. Metz, High Street Chambers, Coventry.

15,994. Shade devices (C.S.). July 28. C. W. Frauenlob, 4, Corporation Street, Manchester.

16,151. Arc Lamps. July 30. The Jandus Arc Lamp and Electric Co., Ltd., and A. D. Jones, Hartham Works, Hartham Road, Holloway.

16,311. Lamp holders. August 1. F. W. Russell, Prudential Buildings, Albert Street, Nottingham.

16,695. Incandescent lamps. August 8. Cutler, Wardle & Co., Ltd., and W. Wardle, 55, Market Street, Manchester.

16,797. Arc lamps (C.S.). August 10. T. J. Rensing, 24, Southampton Buildings, London.

17,140. Carbons for flame arc lamps. August 14. S. Paterson and C. H. Tubbs, Birkbeck Bank Chambers, London.

II.—GAS LIGHTING.

14,790. Gas lamps. July 13. G. Helps, Izons Croft, Ausley, Atherstone.

14,835. Inverted incandescent lamps. July 13. A. E. Podmore and J. Thomas, 256, Croxted Road, Herne Hill, London.

14,979. Gas harp pendants. July 15. A. Raybould and A. E. Seymour, 9 Fleet Street, Birmingham.

15,143. Gas pendants and burners. July 17. G. Helps, Izons Croft, Ausley, Atherstone.

15,217. Inverted incandescent burner protecting the mantle from shock. July 18. H. Pullen, 24, Listerhills Road, Bradford, Yorks.

15,263. Gas lights. July 18. H. F. Boughton and A. Cruickshank, 276, High Holborn, London.

15,549. Manufacture of incandescent mantles (C.S.). July 22. S. Cohn, 11, Southampton Buildings, London.

15,630. Illuminating apparatus for intermittent signs (C.S.). July 23. R. Ullrich, 7, Southampton Buildings, London.

15,644. Incandescent burners. July 23. W. Sugg & Co., Ltd., and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.

15,845. Converting pendant with upright incandescent burner into one with inverted burner (C.S.). July 25. (I.C. Feb. 11, 1908, Germany.) F. Heuer, 19, Holborn Viaduct, London.

16,074. Inverted burners (regulating air and preventing back lighting). July 29. J. Dittrich, 15, Ampton Street, Gray's Inn Road, London.

16,278. Lamps (C.S.). July 31. W. E. Lake, 7, Southampton Buildings, London. (From Aurora Illuminating and Mantle Co., U.S.A.)

16,351. Automatically lighting or extinguishing gas lights. Aug. 1. G. Robson, 18, Southampton Buildings, London. (Addition to 20,109/07.)

16,364. Chronometers for lighting or extinguishing burners (C.S.). Aug. 1. C. Gagliazzo, 111, Hatton Garden, London.
16,645. Mantles. Aug. 7. W. G. Potter, 18, Fulham Place, London.
16,979. Support for gas lanterns (C.S.). Aug. 12. J. Gunning, Birkbeck Bank Chambers, London. (Addition to 2,960/08.)
17,007. Inverted incandescent mantles. Aug. 13. F. Nemerovsky, 55, Market Street, Manchester.
17,125. Incandescent lamps. Aug. 14. G. King, 65, Chancery Lane, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

14,809. Candle lamp (C.S.). July 13. J. R. Churchill, 22, Abbeyfield Road, Sheffield.
14,989. Lamps and apparatus for burning carburetted air. July 15. W. G. Potter, 14, Ingleton Street, Brixton Road, London.
15,337. Acetylene generator and torch (C.S.). July 20. A. F. Jenkins, 19, Farringdon Street, London.
15,691. Electric and other lamps. July 24. W. H. Dee, W. Dee, and F. J. Edginton, Criterion Works, Bow Street, Birmingham.
15,878. Lamp burners with detachable cones. July 27. F. Sherwood, 11, Burlington Chambers, New Street, Birmingham.
16,331. Illuminated advertising devices (C.S.). Aug. 1. F. W. Bundy, 8, Portugal Street, Lincoln's Inn, London.
16,448. Combustible mixtures for producing actinic light (C.S.). Aug. 4. C. Bethge, 111, Hatton Garden, London.
16,458. Incandescent burners for petroleum or petroleum spirit (C.S.). Aug. 4. J. Daugarou, 118, Holborn, London.
16,602. Incandescent petroleum lamps (C.S.). (Aug. 6. I.C. Nov. 8, 1907, Italy). G. Bas, 33, Cannon Street, London.
16,952. Method of lighting lamps (gas, oil, or candle). Aug. 12. A. H. Hathaway and E. D. Round, 15, Mansel Road, Smallheath, Birmingham.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

16,503. Attaching tungsten filaments in glow lamps (C.S.). I.C. May 6, 1907, Germany. Accepted July 22, 1908. Deutsche Gasglühlicht Akt.-Ges. (Auerges.), 55, Chancery Lane, London.
16,719. Arc lamps for signalling and for search lights. July 22, 1907. Accepted July 29, 1908. G. Forbes, 24, Southampton Buildings, London.
17,059 Arc lamps. July 25, 1907. Accepted July 29, 1908. E. R. Grote and M. V. Ely, trading as Foster & Co., Worple Road, Wimbledon.
17,346. Holders for incandescent lamps. July 29, 1907. Accepted July 29, 1908. R. T. Preston and H. E. Theobalds, 77, Chancery Lane, London.
17,661. Switch for series lighting. Aug. 2, 1907. Accepted Aug. 12, 1908. H. J. Dowsing, 24, Budge Row, London.
17,718. Arc lamps (C.S.). I.C. Aug. 2, 1906. Accepted Aug. 12, 1908. Deutsche Beck-Bogenlampen G. m. b. H., 27, Chancery Lane, London.
18,053. Filaments for incandescent lamps. Aug. 8, 1907. Accepted Aug. 12, 1908. R. Jahoda and Electrische Glühlampenfabrik "Watt," 7, Southampton Buildings, London.
18,573. Controlling electric lamps or signs (C.S.). Aug. 16, 1907. Accepted July 22, 1908. J. Cole, 1, Broad Street Buildings, Liverpool Street, London.
19,157. Filaments for lamps. Aug. 26, 1907. Accepted Aug. 12, 1908. O. Imray, Birkbeck Bank Chambers, London. (From Glühlampen-Fabrik "Union," G. m. b. H., Germany).
19,672. Metallic filaments for glow lamps (C.S.). I.C. Aug. 2, 1907, Germany. Ges. für Verwertung Chemische Produkte, m. b. H., 55, Chancery Lane, London.
20,619. Holder for incandescent lamps. Sept. 17, 1907. Accepted July 22, 1908. C. M. Escaré and C. Damey, 9, Osborne Road, Thornton Heath, Surrey.
23,043. Arc lamps (C.S.). Oct. 18, 1907. Accepted July 22, 1908. D. Timar and K. von Dreger, 7, Southampton Buildings, London.
4,762. Electrodes for arc lamps (C.S.). I.C. March 1, 1907, Germany. Accepted Aug. 12, 1908. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
6,229. Arc lamps for theatrical stages, &c. (C.S.). March 20, 1908. Accepted July 22, 1908. T. J. Digby, 37, Essex Street, Strand, London.
7,328. Arc lamps (C.S.). I.C. Aug. 2, 1907, Germany. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
9,479. Supporting hooks for lamp filaments (C.S.). I.C. May 3, 1907, Germany. Accepted July 29, 1908. W. Schäffer, 31, Bedford Street, Strand, London.
9,501. Arc lamps (C.S.). May 1, 1908. Accepted July 29, 1908. H. Baggett, 88, Chancery Lane, London.
12,682. Arc lamps (C.S.). I.C. July 15, 1907, Germany. Allgemeine Elektricitäts-Ges., 83, Cannon Street, London.
16,534. Refractory conductors (C.S.). I.C. August 7, 1907, U.S.A. W. D. Coolidge, 83, Cannon Street, London.

II.—GAS LIGHTING.

16,213. Gas lamps and burners. July 15, 1907. Accepted July 22, 1908. R. J. Russell, 275, High Road, South Tottenham, London.
17,442. Inverted incandescent burners. July 30, 1907. Accepted Aug. 6, 1908. F. Turner, 77, Chancery Lane, London.

20,330. Inverted incandescent burners. Sept. 12, 1907. Accepted July 29, 1908. W. Cross & Son, Ltd., and J. Kirby, 24, Temple Row, Birmingham.
20,933. Gas illuminated "flash" advertisements. Sept. 20, 1907. Accepted July 22, 1908. D. Assersohn, 7, Southampton Buildings, London.
27,455. Inverted incandescent lamps. Dec. 12, 1907. Accepted July 29, 1908. S. J. How and E. S. Wright, 6, Bream's Buildings, Chancery Lane, London.
2,572. Mantles for incandescent lighting (C.S.). Feb. 5, 1908. Accepted July 29, 1908. M. Weickert, 37, Essex Street, Strand, London.
7,309. Controlling gas supply to lamps at a distance (C.S.). I.C. July 23, 1907, Germany. G. Himmel, 18, Southampton Buildings, London.
9,362. Suspending device for gas lamps. April 30, 1908. Accepted Aug. 12, 1908. W. H. Clupperfield, 149, Strand, London.
10,233. Incandescent mantles (C.S.). May 11, 1908. Accepted Aug. 12, 1908. A. Simonini, 332, High Holborn, London.

III.—MISCELLANEOUS.

(including lighting by unspecified means, and inventions of general applicability).

16,599. Reflectors, for search lights, &c. July 19, 1907. Accepted July 22, 1908. The Hon. C. A. Parsons, G. G. Stoney, and E. Bennett, 18, Southampton Buildings, London.
17,716. Petroleum and like lamp burners. August 2, 1907. Accepted August 6, 1908. T. Andreasen, 4, South Street, Finsbury, London.
28,495. Lamps. December 27, 1907. Accepted July 22, 1908. Clarke's "Pyramid" and "Fairy" Light Co., Ltd., S. B. Clarke, and H. Clarke, 24, Southampton Buildings, London.
3,159. Suspension device for incandescent bodies (C.S.). I.C., February 20, 1907, Germany. Accepted July 22, 1908. F. Frey, 231, Strand, London.
3,947. Mantle rings, burner nozzles, insulators, and other incombustible articles for gas and electric fittings (C.S.). February 21, 1908. Accepted July 29, 1908. A. A. Lines, 33, Chancery Lane, London.
8,010. Acetylene burners (C.S.). April 10, 1908. Accepted July 29, 1908. D. J. Van Praag, 18, Southampton Buildings, London.
10,225. Lantern holders (C.S.). I.C. June 6, 1907, U.S.A. Accepted August 6, 1908. C. W. Leaning, 53, Chancery Lane, London.
15,746. Long distance lighting (C.S.). I.C. July 25, 1907, Germany. J. Lafitte, 111, Hatton Garden, London.
17,148. Automatic ignition and extinction of lamps (C.S.). I.C. August 16, 1907, Sweden. E. A. Fagerlund, 18, Southampton Buildings, London.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.—Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

TRADE NOTES.

We have received from the *Linolite Co.* some particulars of the "Tubolite" reflector, accompanied by an intimation that two new patterns have been introduced; also that a substantial reduction is to be made in the price of the fitting, which will in future be sold at 7*s*. 9*d*. per foot.

We have also to acknowledge, among other publications, the receipt of an illustrated list of lamps and fittings from the *British Westinghouse Co., Ltd.*, some particulars of recent types of searchlights from *Messrs. Siemens Bros., Ltd.*, and an illustrated catalogue of oscillographs from the *Cambridge Scientific Instrument Co, Ltd.*

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EDITORIAL.

The Standard of Light at the National Physical Laboratory.

The communication of Dr. Glazebrook, the Director of the National Physical Laboratory, to the British Association on the subject of the standard of light adopted at the Laboratory is an exceedingly important one in several respects.

Briefly, it is proposed to alter the method of specifying the amount of water vapour present per cubic metre of air in the photometer-room, the value of which previously was measured by the unventilated wet and dry bulb hygrometer. This is now to be measured by the aid of the Assmann ventilated instrument, which has been employed in Germany for this purpose. It now appears that the percentage of water vapour that would have been registered on the unventilated instrument as 10 litres per cubic metre of air would be indicated by the ventilated instrument as 8 litres. As the Assmann instrument is believed to be the more trustworthy instrument of the two, and as it is employed on the Continent, it is now proposed also to adopt this instrument for use with the British standard and to call the standard amount of water-vapour 8 litres per cubic metre of air in future.

One important result of the discovery of the difference in reading between the two instruments will be that the relations between the standards of light employed in England and on the Continent will need revision. This seems to lead to a fortunate simplification, namely, that the Hefner unit will in future be deemed to be practically 0·9 times the British pentane unit, while the Bougie decimale and the British unit come into practical equality. This may naturally affect any future decisions as to the possibility of adopting a convenient international unit.

A second interesting result arising from this discovery of the difference in the results obtained by the two forms of hygrometers is that the old discrepancy between the relations of the standards in different countries, as determined by direct comparison, and as obtained by the interchange of

standardized incandescent lamps, is now partially accounted for; there still remains a small error of something over 1 per cent, however, and this is now being investigated jointly by the National Physical Laboratory and the Reichsanstalt. To some it may appear hardly necessary to attempt to obtain such consistency in photometrical measurements as the above percentage indicates, but we are more disposed to feel that in standard work of this kind the existing progress in this direction, though marvellous under the circumstances, still leaves something to be desired.

Apart from this aspect of the matter, however, we think that the moral effect of this steady removal of all the old sources of uncertainty can scarcely be overestimated. We are unable to agree with those who seem to see in the discovery of these unsuspected errors some ground for objection to the work on which it is based. At one time, when such investigations had not yet been undertaken, the cumulative effect of unrecognized errors of this kind was not infrequently ascribed to personal error; thus it came about that photometry came to be regarded as a hopelessly unreliable process, to the arbitration of which commercial matters could never be subjected. Now, however, the old sources of uncertainty are being one by one recognized and removed, and it must now be recognized that photometry, well within the limits of accuracy imposed by commercial consideration, is possible. There is still much to be done before one could say that photometry has become an exact science in the true sense of the word. We are however approaching those conditions.

An International Unit of Light.

The International Conference upon Electrical Units is to take place in London on October 12th, and will be followed by the meeting of the International Electrotechnical Commission on the 19th. It is probable that the latter conference will come to some conclusions of considerable interest to illuminating engineers with regard to the possibility of establishing a common unit of light. We understand that the French National Committee have made the suggestion that in future the British candle should be raised 2 per cent and the United States candle lowered 2 per cent, the French intermediate unit remaining unaltered, so that the three units would be brought into practical agreement. This suggestion, however, will now have to be considered anew on account of Dr. Glazebrook's communication to the British Association on the subject of the National Physical Laboratory standard. According to the text of this communication, which is dealt with elsewhere, the relations hitherto accepted as correct between the standards of light in the different countries will have to be subjected to revision.

The Testing of Flame Arc-Lamps and Incandescent Gaslights.

We notice, in a recent number of the *Gas World*, some comments by Mr. W. H. Y. Webber upon the two articles by Prof. J. T. Morris, which were published in our last two numbers. We appreciate Mr. Webber's recognition of the value of these articles and welcome his discussion of the matter, if only as an illustration of the necessity that both gas and electrical engineers should come forward and express their views on disputed points.

One point to which Mr. Webber refers is the conventional method of expressing the performance of an incandescent gas lamp in terms of the intensity of the horizontal beam. This custom, Mr. Webber explains, is merely a derivation of the old system of testing the performance of a variety of gas, and is not devised with the object of selecting the direction of maximum intensity. It answers for the comparison of different qualities of gas or for the comparison of different lamps giving exactly the same variety of distribution-curve. But it is clearly

misleading when applied to the comparison of lamps that differ considerably in this respect, and if so used is, as Mr. Webber does not fail to point out, quite likely to be the cause of much misunderstanding. Whether we elect to base our comparison of gas and electric lamps on mean spherical or mean hemispherical C.P. or neither, it is at least desirable that there should be a common understanding between those in both professions on the matter, and we cannot see why some form of concerted action to this end, such as that recently undertaken by the Institutions of Gas and Electrical Engineers in Germany, should not also be possible in this country.

Another question touched on by Mr. Webber—the value of street-lights from a decorative point of view—constitutes very debatable ground, and is really a problem entirely distinct from the use of light for purely illuminating purposes.

Some people apparently consider a long row of lamps decorative. Others, while admitting the æsthetic possibilities of light so used, only recognize in most modern sources, disagreeably bright and glaring points of light that interfere with the clear view of the background, and call for some method of shading. Moreover, many people do not really base their judgment on the illumination at all, but only on the degree of apparent brightness of the lamps themselves. We do not ignore the æsthetic possibilities of street-lighting, but we do think that the time has come when these two aspects should be distinguished from one another, and the question of what constitutes artistic lighting more carefully studied.

Electrical and Gas Supply Companies and Illuminating Engineering.

We have repeatedly called attention to the growing recognition of the importance to supply companies of studying the conditions at the consumer's end of the wire or pipe, and in this number some reference is made to the recent articles of Mr. A. J. Marshall, of the Illuminating Engineering Bureau of New York, bearing on this point. It was pointed out that the company is bound to bear at least a share of the odium resulting from high bills and poor lighting, and it is obviously to their interest to do all that is possible to obtain the consumers' confidence.

Not a few of the manufacturing companies in the United States have for some time maintained departments of illuminating engineering to deal with such problems. The General Electric Co. have a special Bureau in Schenectady, but we believe that the Edison Electric Illuminating Company of Boston are the first electrical supply company actually to organize an expert staff of illuminating engineers from whose advice consumers and supply company will both benefit. In this Bureau they have acquired the services of Dr. Louis Bell, who is, the President of the Illuminating Engineering Society this year, and who is to supervise the work of the department.

We understand that the efforts of the company in this direction have already met with an immediate response, and we do not doubt that they will reap the benefit of their foresight and enterprise, and that their example will shortly be followed by others.

The Educationalist, the Physiologist, and the Illuminating Engineer.

The meeting of the British Association this year served to show in a very marked manner how many points of interest the physiologists and those interested in education have in common.

Prof. Sherrington, Prof. F. Gotch, and others all pointed out the importance of those who are concerned with the education of children knowing something about the minds and bodies of those they teach, in order that they may be able to guard against the

possibility of introducing methods of teaching or injurious local conditions which may prejudice the health of the children.

Some of those present spoke of the difficulty in securing the support that the vital importance of this subject demands. We ourselves, therefore, can understand how the particular physiological conditions with which we are mainly concerned—the provision of adequate lighting arrangements—has not always received the public recognition that it deserves.

Nevertheless it is only necessary to reflect how great a proportion of the impressions of the growing child are derived through the eyes to understand how important it is that these organs should be well served in the matter of illumination. All this we have said in greater detail in our first number ('ILLUMINATING ENGINEER,' Vol. I., Jan. p. 58). On this occasion we supported our suggestions by quoting the opinions of many of the medical profession, and pointed out that a system of medical inspection of schools, intended to include tests of eyesight, ought logically also to include tests of the defective conditions of illumination responsible for the eye troubles investigated.

In the report of the Committee on the 'Conditions of Health essential to the Carrying on of the Work of Instruction in Schools,' no reference whatever is made to the conditions of the illumination in schoolrooms, and we hope that this omission in its scope may be made good. This is the more to be desired because the report concludes with the suggestion that a Royal Commission should be appointed to deal with the matter, and the vital necessity for good illumination should not be overlooked.

The Editor, who visited the meeting of the British Association with the express object of learning the views of physiologists on these questions, received ample assurance that the medical profession thoroughly recognize the necessity for studying the physiological principles underlying good illumination.

Illuminating Engineering Literature.

On the 5th and 6th of this month is to be held the second Annual Convention of the Illuminating Engineering Society in the United States. We have already published the list of papers to be read (see 'ILLUMINATING ENGINEER,' August, p. 697), and pointed out the wideness of the ground to be covered by them; with these papers we mean to deal in detail in a subsequent number.

Meantime, it is to be noted that the number of sources of information relating to illuminating engineering is already legion, and, in contrast to the premature predictions in some inadequately informed quarters, the ever-growing developments of the subject promise yet more numerous and valuable additions to the existing literature.

In the United States, for example, the subject now forms an integral portion of the discussions of many local societies and of many of the foremost technical journals. We note, for instance, that both the *Electrical World* and the *Electrical Review* of New York have, in their recently issued special numbers devoted to the progress of electric lighting, included general articles on illuminating engineering; this is surely an interesting indication of the general demand for information of this nature. The experience of these two periodicals, however, is evidently shared by many other technical journals here and on the Continent, who, though but a few years ago would not have dreamed of including illumination in their scope, now regularly publish articles more or less directly bearing on the subject.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 799) now enters upon a description of the CHIEF FORMS OF PHOTOMETERS, and contributes a few general remarks on the classification of such instruments, explaining that the vast majority of existing types, though differing considerably in matters of detail, are yet subject to the same general principles. He also refers to some of the early work of Bouguer, and describes the form of photometer with which his name is connected.

Dr. M. Corsepius (p. 801) describes a series of original investigations on a new method of MEASURING MEAN HEMISPHERICAL CANDLE-POWER WITH THE ULBRICHT GLOBE.

This is accomplished by inserting a specially designed vessel within the globe in such a way as to completely absorb all the light emitted by the source examined in one hemisphere. The advantages of the method are fully explained; the author also discusses in detail some of the possible sources of errors, including those due to the presence of "foreign bodies" within the globe.

Dr. F. W. Edridge-Green (p. 807) gives some account of the PHYSIOLOGICAL BASIS OF COLOUR AND LIGHT PERCEPTION. He gives some account of the functions attributed to the action of the "rods" and "cones" on the retina and of the visual purple, and proceeds to explain his theory of colour-blindness. Finally he remarks upon the importance of lighting a room satisfactorily from the physiological standpoint, and states that the question as to best quality of light for ordinary purposes requires further investigation, before any definite opinion can be expressed.

Mr. Percy J. Waldram (p. 811) contributes a second article dealing with the MEASUREMENT OF DAYLIGHT ILLUMINATION FROM THE ARCHITECT'S STANDPOINT. He describes a modification of the Trotter Photometer, specially devised for the purpose of measuring a wide range of daylight illumination, and enters into the theoretical principles underlying the use of the instrument. As a result of his investigations Mr. Waldram confirms the result of Dr. Ruzicka (*Illuminating Engineer*, Vol. I. July), to the effect that, for a uniformly illuminated sky, a constant relation between its intrinsic brilliancy and the resulting illumination at any given point in a room exists, and suggests the possibility of predetermining the illumination in a building by the aid of a small specially constructed model.

Mr. B. Duschnitz (p. 817) describes a new form of METALLIC FILAMENT LAMP FOR HIGH PRESSURE AND SMALL CANDLE-POWER. In this case the plan of utilizing a small carbon filament glow-lamp mounted permanently in series with a metallic filament is adopted. By this means the inconvenience of being obliged to make such a very long thin filament is avoided, and, it is claimed, only at the cost of a small loss of efficiency. The lamp, as a whole, is stated to give about 1·54 watts per H.K., and has also the incidental advantage that the initial rush of current taking place in the case of the cold metallic filament is very greatly reduced by the high cold resistance of the small series carbon filament.

Dr. C. V. Drysdale (p. 821) continues the section of his series of articles dealing with the LAWS AND MEASUREMENT OF RADIATION. The present instalment contains a description of several of the best-known sensitive instruments utilizing the principle of the thermopile for the measurement of radiation; among the instruments described in Dr. Drysdale's article may be mentioned the Boys radiomicrometer and the Angstrom Pyrheliometer.

Mr. Lancelot Wild (p. 825) describes an IMPROVED FORM OF GREASE-SPOT FLICKER-PHOTOMETER, enabling the operator to observe both sides of the screen, and thus to balance the "flicker" in each case by a process analogous to the "contrast" method; this modification is said to lead to increased sensitiveness.

The **Special Section** in this number is devoted to the second of the series of descriptions of well-known laboratories in different countries. On this occasion **Mr. C. C. Paterson** and **Mr. E. H. Rayner** (p. 845) describe the PHOTOMETRIC ARRANGEMENTS AT THE NATIONAL PHYSICAL LABORATORY. The article is fully illustrated, and includes a discussion of the various errors experienced in standard work and the methods by the aid of which they are avoided. These methods are illustrated by views of the test benches, the extent of the scale of the standard voltmeter, &c., and the "substitution-method," as employed at the Laboratory, is described. Some details of the general work of the laboratory are also given, including the method of carrying out life-tests, and the nature of the equipment available for this purpose.

Among other articles in this number attention may be drawn to that on p. 819 describing some of the methods that are being evolved in the United States in order to facilitate the MUTUAL CO-OPERATION BETWEEN THE SUPPLY COMPANY AND THE CONSUMER, and to win the latter's confidence. An example is furnished by the action of the **Boston Edison Electric Supply Co., Ltd.,** who have organized a SPECIAL DEPARTMENT OF ILLUMINATING ENGINEERING under the supervision of **Dr. Louis Bell,** for the purpose of advising customers in the arrangement of their installations. On p. 827 will be found an article describing a NEW METHOD OF INCANDESCENT GAS LIGHTING, utilizing bundles of small rod-filaments, instead of the usual mantle; it is claimed that such bundles are much less fragile than mantles of the ordinary variety. Particulars are given by **Mr. H. Koffler** (p. 829) of a new method of making CARBIDE "BRIQUETTES" for the generation of acetylene. The generation of acetylene from this material is said to take place very uniformly, and the old trouble of "after-gassing" is avoided.

The continuation of the article on the effects of light upon the human body discusses some physiological EFFECTS OF THE LIGHT WITHIN THE VISIBLE SPECTRUM (p. 836), including the so-called "depressing" and "exhilarating" influences ascribed to the rays from the violet and red ends of the spectrum.

Another article contains some further examples of shop-window lighting by gas; there will also be found a brief résumé of the chief points of interest, from the standpoint of illumination, at the RECENT MEETING OF THE BRITISH ASSOCIATION (p. 831). Special interest attaches to the communication of **Dr. Glazebrook** relating to the proposed alteration in the conditions by which the candle-power of the STANDARD OF LIGHT AT THE NATIONAL PHYSICAL LABORATORY is in future to be specified, and their influence upon the standards of light in different countries.

The present number also contains an abstract of the recent discussion upon the paper by **Drs. Schanz** and **Stockhausen** (abstracted in our last number p. 772) relating to the EFFECTS OF ULTRA-VIOLET LIGHT UPON THE EYE (p. 853). While the suggestions of the authors did not escape criticism, it was agreed that the point raised was an important one to the lamp industry, if only on account of the apprehensions to which such possibilities give rise.

Some account of the recent papers by **Prof. W. Wedding** (p. 858) and **Herr H. Remané** (p. 861), before the Verband Deutscher Elektrotechniker are also included in this number; they contain some exhaustive particulars of TESTS AND CALCULATIONS COMPARING THE MERITS OF THE NEWER ELECTRIC ILLUMINANTS, including the results of a series of tests on modern metallic filament lamps. A recent article on the "OVERSHOOTING OF TUNGSTEN LAMPS" will be found on p. 868.

Dr. E. W. Marchant and **Prof. J. T. Morris** write to our columns discussing the absorption of the globes of flame arc-lamps (pp. 870 and 871) and **Mr. K. Sartori** replies to a comment on the TEMPERATURE OF THE SUN (p. 868).

For the usual **Review of Current Literature dealing with Illumination** and the **Patent List,** see pp. 873-80.

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,
Electrical Adviser to the Board of Trade.

(*Continued from p.* 716.)

Photometers. — At first it would seem that photometers ought to be divided into two classes, one for measuring the candle-power of a source of light, and another for measuring the illumination at a given point on a plane set at a given angle and aspect. But on closer examination it is found that any instrument of the second class may be used with more or less convenience for measuring candle-power, and that every candle-power photometer depends on the observation of the illumination of a screen or screens. Those types which are peculiarly adapted for the measurement of illumination, and are less well suited for measuring candle-power, may be called illumination-photometers. It would be beyond the scope of these articles to go minutely into the details of ordinary visual photometers. A brief description of a few leading types will be given, sufficient for the purpose of the engineer who desires a general knowledge of the subject. It will be shown how these types, though at first sight appearing very different, and having no structural resemblance whatever are in fact so closely related, that intermediate kinds may be found, filling up all the gaps. Visual photometers are in general a class of apparatus in which there is a gradual transition from each pattern to some other, and there is very little to choose between them.

Since this somewhat peculiar relation exists, it does not matter where we enter the line, and we may as well begin with the first three patterns in historical order, quoting the original description, and reproducing the illustrations.

The Bouguer Photometer.—No writers on optics up to the beginning of the eighteenth century seem to have paid attention to comparisons of intensities of lights. Although several proposals had been made by astronomers for measuring what may vaguely be called "light," Pierre Bouguer,* Professeur Royal en Hydrographie, seems to have been the first to recognize the conditions and to describe scientifically correct methods of photometry. In 1729 he published his 'Essai d'Optique sur la Graduation de la Lumière,' and in 1757 contributed a paper on 'Means for Measuring Light, and some Applications of these Means,' to the Academie des Sciences. It is to be found in the 'Mémoires de Mathématiques et de Physique' of that year. Many photometrical experiments are described in these writings, but without going into instrumental details.

Bouguer died in 1758, and two years afterwards the Abbé de la Caille edited his papers, and the 'Traité d'Optique sur la Graduation de la Lumière' was

* Bouguer took part in the expedition which Louis XV. sent in 1735 to Peru to measure an arc of meridian; he invented the heliometer.

published as a volume of the Académie des Sciences.

He alluded to a little book by a Capuchin Père François Marie, 'Nouvelles Découvertes sur la Lumière' published in 1700. "When he wished to measure the strength (*la force*) of a light he tried how many pieces of glass or of separate mirrors he had to use to make it completely disappear ....in the same way as several other people who fell into the same error; but what rendered his expedients more defective, was the bad use he made of them." He pointed out several objections to this method, which has often been revived in different forms. "The different state of the observer's eyes, being more or less sensitive at one time than another or being fatigued. Each observer would then attribute a different value to the light which he measured. It is not possible to agree when observing at different times....and the measurements never gave the exact ratios."*

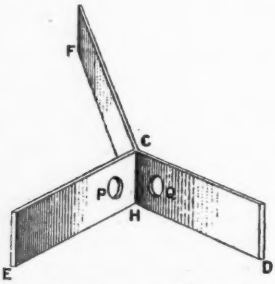


FIG. 47.—Bouguer's Photometer.

On p. 9 of the 'Traité d'Optique' he describes an arrangement which, though primitive, must be recognized as the first photometer. "To receive the two lights to be compared a simple piece of cardboard E C D as seen in Fig. 47), may be used, which has a fold C H, so that each half of the surface may be exposed more perpendicularly to each light, the whole of this piece of cardboard is black, but it has two holes of exactly the same size, say of three or four lines in diameter to which paper soaked in oil, or two perfectly equal pieces of glass, are applied, and these are made equally mat or white with emery or gritstone. The oiled paper or the mat glass are sometimes more transparent than necessary, and I have more often used two pieces of ordinary very fine and very white paper, which I took side by side from the same sheet. I let the two lights fall on these two pieces of paper, and I judged the equality of their force by looking at them from behind, or sometimes from in front. A second piece of cardboard F C served as a diaphragm, and prevented the two lights from mixing before illuminating the two little surfaces P and Q. This diaphragm was black on both sides, and joined to the first piece of cardboard exactly at the ridge which formed the fold."

After describing how lenses may be used to adjust the illumination of the two spots, when it is not convenient to move the lights, and how the "force" may be calculated from the relative positions of the lenses, he goes on to say: "At length I noticed that another point of which I have already spoken is not less important; it is to give exactly the same shape and same size to both parts P and Q which serve as images or pictures to make all the circumstances exactly the same for the observer who examines them. The two illuminated images cannot be too close one to the other; it is absolutely necessary for them to be seen at one glance, and it would be a good thing, if possible, to make their edges such as to touch each other. I have almost always looked at these same images through a hole made in another diaphragm, which I applied at some distance from the eye, and which hid everything else from me."

While the arrangement shown in Bouguer's illustration (Fig. 47) has not much to recommend it, the developments suggested in the last two sentences of the description convert it into nothing less than the photometer officially used by the Metropolitan Gas Referees at the present day.

* Bouguer, 'Traité d'Optique,' p. 46.

(*To be continued.*)

The Measurement of Mean Hemispherical Candle Power by the Aid of the Ulbricht Globe Photometer.

By Dr. M. Corsepius.

When Ulbricht, eight years ago, brought out his globe photometer,* he had in view certain limited applications of the instrument, especially its use for the purpose of comparing different varieties of carbons intended to be subsequently employed in arc-lamps of a certain kind. At that time a globe photometer 50 cm. in diameter was considered adequate for the purpose of ordinary arc-lamp photometry, this diameter being selected to correspond with the usual dimensions of the globes of arc-lamps. Subsequently it came to be recognized that the greater the diameter of the globe photometer the more easily could the incidental errors of measurement be avoided. It was on the advice of Prof. Ulbricht that the author, when designing such a photometer in 1904, selected a diameter of 2 metres; this value, however, has frequently been equalled and, indeed, exceeded since that date.

But not only a gain in accuracy, but also an extension of the uses of the instrument was achieved in this way. One of the most important links in the chain of improvement has been the application of the globe photometer to the measurement of mean hemispherical candle-power. This application, although in a sense foreign to the actual theory of the instrument, has been very thoroughly worked out by Prof. Ulbricht,† in order to comply with the increasing importance attached to the measurement of mean hemispherical candle-power as a basis of comparison of different sources of light.

At the same time certain objections have been urged against the adoption of this measurement. In particular it has been contended that a comparison between the arc-lamp and other illuminants is prejudiced by the adoption of this system of rating, that it only conveys a correct impression when applied to the comparison of arc-lamps surrounded by clear glass globes, and that reliable deductions as to the actual illuminating value of different sources cannot possibly be made from a knowledge of the mean hemispherical candle-power alone. Arc-lamps are almost invariably provided with opal glass globes or other distributing shades or reflectors. Hence it follows that a separate measurement for each globe is necessary, and the difficulty also arises that photometrical observations must be made at a finite distance from the source, and that the exact position of the "radiant centre" and the plane passing through it from which the portion of the light thrown into the hemisphere is reckoned, is often uncertain.

It was largely this circumstance that induced Ulbricht to contrive a further means of overcoming this difficulty, and his efforts led to the introduction of an instrument for the purpose of determining the position of the radiant centre; this piece of apparatus is of the greatest value, not only in measurements executed with the globe photometer, but also in the cases of all other problems involving the distribution of light in space.

Recent experiments seem to suggest that even in the case of glow-lamps, the filaments of which certainly approach linear dimensions, the mean spherical candle-power is coming to be regarded as the only trustworthy basis of comparison. For instance, Wedding in a paper read at the annual meeting of the Verband Deutscher Elektrotechniker, presented a large number of values of the mean spherical candle-power of glow-lamps of different varieties, and insisted upon the necessity of expressing results in this way.*

The method proposed by Ulbricht

* *E.T.Z.*, 1900, p. 595 *et seq.*
† *E.T.Z.*, 1906, 3, and 1907, 32.

* *E.T.Z.*, 1908, 31, p. 730.

to adapt his instrument to the measurement of mean hemispherical candle-power has been described in his publications. According to this method a portion of the inner surface of the globe is either actually removed or rendered ineffective by covering it with some non-reflecting material.

Meantime certain rules and recommendations have been issued by the Verband Deutscher Elektrotechniker, relating to the photometry of arc-lamps. In opposition to the general suggestion that only the mean hemispherical candle-power should be measured, put forward but not accepted in 1906, it has now been laid down that *both* the mean spherical candle-power and the mean hemispherical candle-power should be determined, and that this should be indicated by the nature of the symbols representing the actual results.

The method of determining the mean hemispherical candle-power proposed by Ulbricht has the practical consequence that the arc-lamp must be tested under two distinct sets of conditions. This involves the removal of the photometer for both experiments, and necessitates another and more elaborate calibration. For, since the direct rays from the standard lamp must not be allowed to strike the blackened region of the inner surface of the sphere, the lamp has to be provided with a partial screen, and the effect of this screen allowed for by a special measurement.

In what follows I propose to describe a piece of apparatus designed and tested by me, which simplifies the double measurement, and enables it to be carried out in a more convenient manner. This device makes it possible both for the globe photometer to remain in the same condition throughout, and for the lamp to remain in the same position; it is also unnecessary to extinguish the lamp during the tests.

According to my method I do not alter the inner surface of the sphere with the object of rendering the light in the upper hemisphere inactive and, consequently, measuring the light-flux in the lower hemisphere. I measure the light from either the lower or upper hemisphere, the light from one of the hemispheres being obstructed by a specially contrived and shaped vessel introduced into the globe photometer and represented by "g" in Fig. 1.

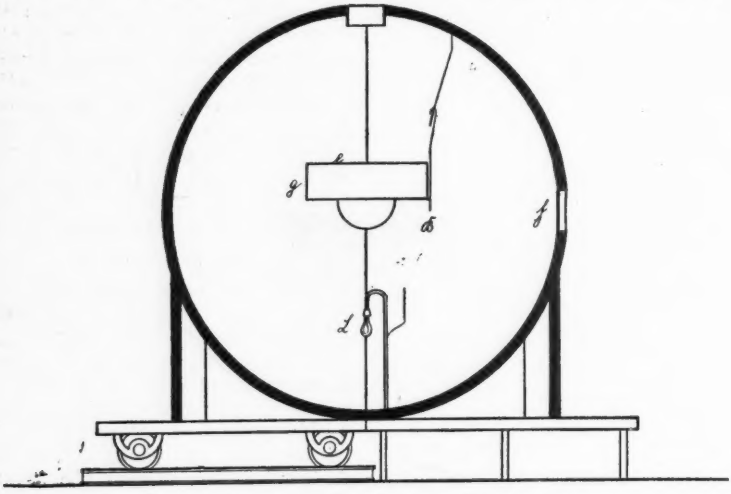


FIG. 1. Showing Vessel within the Ulbricht Globe.

In order to render the conditions of measurement as perfect as possible, it is essential for the inner surface of the vessel "g" to be dead-black, and the outer surface dead-white. The actual shape of the vessel is immaterial: for instance, it may take the form of a

cylinder, a hemisphere, a cone, or as shown in Fig. 1, a vessel built up by utilizing two or more of the shapes specified. The face e occupies the horizontal plane passing through the radiant centre of the source, and must consist of a circle of sufficient diameter to comply with the conditions laid down by Prof. Ulbricht.

In Fig. 2 is shown a photograph of a hemispherical vessel in position within the globe.

By this arrangement it is possible to bring the radiant centre of the lamp into a position intermediate between the centre of the globe, and a point distant 0·58 times the radius ($\alpha=30°$), this being the situation that favours the reduction of errors to a minimum. The circle of section (*i.e.*, the face of the vessel introduced into the photometer) may also be at a distance from the vertical axis of symmetry equal to the length of the diameter of the smallest sphere, capable of including the radiating surfaces of the source tested, and this without the diffusing action of the white inner wall of the globe being appreciably affected.

The combination in the vessel of two distinct portions renders it possible to employ a smaller circle of section in the case of lamps having relatively small globes, than when the globe is comparatively large; of course it is also open to the experimenter to employ two entirely separate vessels in the two cases.

The process of calibration is simpler than was the case when the previous method of using the photometer was employed. All that is necessary is to take measurements with the standard lamp in position first with and then without the vessel; moreover, if sufficient data as to the effect of the vessel on different varieties of lamps are available, we may content ourselves with a single calibration, carried out without the vessel, and then apply a known correction for the constant employed when the vessel is introduced into the photometer.

In order to render the calibration especially simple, I have preferred to utilize a calibration-lamp hanging in a vertical position, as shown by the lamp L in Fig. 1. Under these circumstances it is unnecessary to screen the light in an upward direction, and there is also the additional advantage of being able to employ metallic filament lamps, which only burn in a vertical position. This enables us to make use of lamps yielding 100 H.K. or more, and thus to obtain sufficient light to utilize the photometer with a bench of the ordinary kind. Osram 100 H.K. lamps have proved very satisfactory for the purpose; the special lamps selected are caused to burn for a considerable time before use.

It is, of course, essential to take precautions to secure that neither the circle of section e, nor the position of the radiant centre of the lamps employed, can alter with respect to one another.

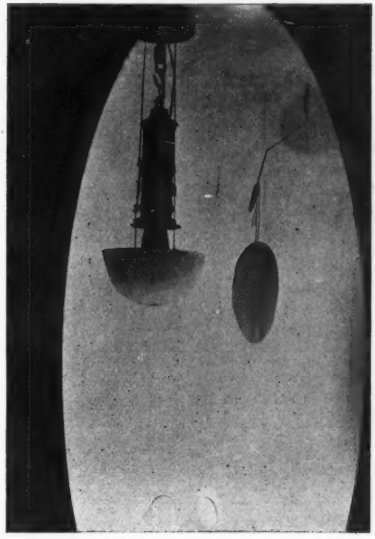


FIG. 2. Showing a small type of vessel in position.

The measurement, on the suggested lines, is carried out as follows :—

After removing the left half of the globe the lamp is introduced into the interior in such a way that its radiant centre falls about the position subsequently occupied by the face of the vessel, and the observer, by sighting towards the window from within the globe, makes sure that the direct rays

TABLE I.

Type of Arc Lamp.	Voltage.	System of Supply.	Current Amperes.	Consumption. Watts.	I_s	I_α	I_ϖ	Watts / H.K.$_\varpi$	K_o	I_α / I_s	Kg Hem.	Kg. Spher.
1. "Carbone" Clear Globe	110	D.C.	7·63	840	676	50	1,252	0·67	0·54	0·08	0·62	0·79
,, ,,			8·06	887	687	59	1,256	0·71	0·55	0·08		
Opal ,, ...			7·55	881	540	149	782	1·06	0·69	0·28		
2. "Radiante" Clear Globe	110	D.C.	8·45	930	683	110	1,146	0·81	0·60	0·16	0·74	0·817
,, ,, ...			8·46	931	678							
Opal ,, ...			8·46	931	588	166	844	1·1	0·70	0·28		
Without Globe ...			8·82	970	754							
3. "Polar" Clear Globe	55	A.C.	9·25	383*	933	26	1,814	0·21*	0·51	0·028		0·55, without resistance
Without Globe ...	55		8·95	387*	1,062	28	2,068	0·19*	0·51	0·026		
,, ,,	110		8·6	895	1,006							
4. "Rebofa" giving white light Regina-Bogl. Fabr. Without Globe ...	37	D.C.	8·9	329	746	120	1,252	0·26	0·595	0·16	0·59	0·69
With Oval Globe ...			8·95	331	517	148	738	0·45	0·70	0·29		
5. "Rebofa" giving white light Regina-Bogl. Fabr. Without Globe ...	37	A.C.	13·3		814	161	1,306	0·36	0·62	0·20	0·53	0·61
With Opal Globe ...			13·8		494	150	688	0·70	0·72	0·30		
6. "Radiante" 4 amp. Clear Globe	110	D.C.	3·95	434	252	abt. 5	494	0·88	0·51	0·02		
Without Globe ...			3·97	437	289	,, 6	566	0·77	0·51	0·02		
7. Siemens & Halske Without Globe ...	55	D.C.	10·52	578	502	9·3	986	0·59	0·51	0·019	0·56	0·75
With ,, ...			10·20	561	367	97	540	1·04	0·68	0·37		

Note.—We have received from Dr. Corsepius some additional data too late for inclusion in the above table. This will be found at the foot of the opposite page.

from the reflector or the diffusing globe surrounding the source, are unable to pass the screen "b" and strike the observation window, "f."

After closing the globe the mean spherical candle-power of the source is measured in the usual way. If it is now desired to obtain the mean hemispherical intensity, the special vessel G is introduced into the interior, the source of light being left in exactly the same position as before, and a second measurement is made. The method indicated in Fig. 1 thus enables us to obtain the mean upper hemispherical candle-power. In order to obtain the mean lower hemispherical candle-power we subtract the value above from the previously determined mean spherical candle-power, and multiply the result by 2. It is desirable, for the sake of increased accuracy, to check the value of either the mean spherical or mean hemispherical candle-power by carrying out a second measurement under slightly varied conditions, and taking the mean of the two observations.

It may next be inquired what order of accuracy may be expected from such determinations. A number of results obtained in the manner described are collected together in Table 1 simply for the purpose of furnishing information on this point. In the sections 1 and 2 some details are given of tests on modern arc-lamps with inclined carbons, both of the ordinary and the "flame" variety, which furnish an almost shadeless illumination below the lamps, and are receiving a considerable amount of attention at the present time.

An observation of the results tabulated under the heading $\frac{I_\Delta}{I_\circ}$ makes it clear that in cases 1 and 3, with clear globes, the light thrown up into the upper hemisphere only amounts to 8 and 2·8 per cent respectively of the total light emitted. The intensity in the upper hemisphere is obtained by the aid of the vessel described, and from the above figures it is clear that a considerable error might be permitted in this determination without affecting the value obtained for the *lower* hemisphere very appreciably. For instance, a 10 per cent error in the determination of I_Δ would, in the two cases cited above, only produce an error of 0·8 per cent and 0·28 per cent respectively, while similarly an error of 3 per cent would only affect the result to the extent of 0·24 per cent and 0·08 per cent respectively, and would, therefore, be entirely negligible.

In the case of lamps with vertical carbons, such as those referred to in sections 2, 4, 5, 6, and 7, the light in the upper hemisphere forms 16, 16, 20, 2, and 1·9 per cent of the total light when clear glass globes are used. The errors corresponding to an error in determination of 10 per cent would, therefore, be 1·6, 1·6, 2·0, 0·2, and 0·19 per cent respectively; while a 3 per cent error in the determination of I_Δ would in the same way cause errors in the result of 0·48, 0·48, 0·6, 0·06, and 0·06 per cent.

In the case of the tests of mean hemispherical candle-power of lamps with opal or other diffusing glass globes (which, be it remembered, are not insisted upon in regulations of the

Additional data received too late for inclusion in Table I.

Type of Arc Lamp.	Voltage.	System of Supply.	Current Amperes.	Consumption. Watts.	I_s	$I_\circ$	Watts H.K.$_\circ$	Ko
8. "Rebofa" (New Type)								
Without Globe ...	37	D.C.	10·1	372	966	1,806	0·207	0·54
With Opal Globe	37		10·2	377	768	1,152	0·328	0·67
9. "Primer" (New Type)								
Without Globe ...	55	D.C.	10·3	567	1,952	3,675	0·154	0·53
With Opal Globe	55		8·7	479	1,470	2,125	0·226	0·69

Verband Deutscher Elektrotechniker previously mentioned), the corresponding contributions to the upper hemisphere amount in sections 1, 5, and 7 to 28, 28, 29, 29, 30, and 37 per cent, so that the error introduced on the previous assumptions in the final results becomes 2·8, 2·8, 2·9, 3·0, and 3·7, and 0·84, 0·84, 0·87, 0·9, and 1·1 respectively. When we recall how greatly different specimens of diffusing glass, even of the same variety, vary among themselves as regards the distribution of light, we may recognize that, even when errors in the determination of the mean upper hemispherical intensity of the magnitude mentioned above are made, the desired results can be relied upon with sufficient exactitude for all ordinary purposes.

The following considerations may furnish a guide as to the prediction of the magnitude of the errors of observation that are likely actually to occur. The vessel G is coated in the interior with a dead-black varnish, that has absolutely no regular reflection. For the purpose of providing this coating I have not availed myself of the ordinary varieties of so-called dead-black varnish nor the black lacquer usually employed for metal work. I preferred to use a special material composed of Frankfort-black added to turpentine with the addition of a small amount of a special adhesive lacquer ("Copallack"). The resulting solution adheres well, and though it is true that it loses colour somewhat when rubbed, that is not of much consequence for the purpose in view.

The introduction of the vessel into the interior of the globe gives rise to errors of the same kind as those due to "foreign bodies," screens, &c., and previously discussed by Ulbricht, though they are here encountered in a somewhat different form. Their magnitude will now form the subject of further investigation. Let

F represent the surface-area of the upper screen.

F_1 represent the surface-area of the lower screen.

a, the angle formed by the line joining the source of light and the window in the side of the globe with the horizontal; and a_1, the corresponding angle formed by the line joining the comparison-lamp and the window, and x and x_o, the distances of the screens from the vertical central line.

a, the coefficient of absorption of the screens.

Then a correction must be introduced into the observed value of the spherical intensity of

$$f-f_1=\frac{F.a}{\pi}\left\{\frac{\cos^7 a}{(2\cos^2 a-1)^2}+\frac{\cos^3 a}{4x^2}\right\}-\frac{F_1 a}{\pi}\left\{\frac{\cos^7 a_1}{(2\cos^2 a_1-1)^2(r-x_o)^2}+\frac{\cos^{-3} a_1}{4x_o^2}\right\}$$ *

In the course of my experiments I eventually settled upon the following dimensions for these quantities:—

F=755	x=33	a=13·5°
F_1=201	x_o=19·5	a_1=30

Thus $f-f_1 = 0{\cdot}566$ per cent for the spherical intensity.

In the same way one can predict the error introduced by the screening action of the vessel G, in conjunction with the error which is called into play by the screening of the lower standard lamp, when the mean hemispherical intensity is being determined. This is expressed by the relation

$$f-f_1=\frac{F.a}{\pi}\cdot\frac{\cos^7 a}{(2\cos^2 a-1)^2 r^2}-\frac{F_1 a}{\pi}\cdot\left\{\frac{\cos^7 a_1}{(2\cos^2 a_1-1)^2(r-x_o)^2}+\frac{\cos^{-3} a_1}{4x_o^2}\right\}$$

Now the plane F is derived by the solid projection of the surfaces of the portions of the vessel inserted in the photometer, from the window of measurement as origin, upon a vertical plane passing through the source of light. In the case of a vessel shaped like that shown in Fig. 1, we have to consider two semi-elliptical surfaces arising from the projection of the edges of the cylindrical portion of the vessel, each 62 centimetres in diameter, and of 362 square centimetres in extent. We have also to take into consideration the projection of the cylindrical portion itself, 1115 square centimetres in area, and lastly, the effect of the hemisphere attached to the base of this cylinder, making F=1900 square centimetres in all. Hence we find that $f - f_1 = 0{\cdot}27$ per cent in the case of observations of mean hemispherical intensity.

(To be continued.)

* See *E.T.Z.*, 1907, p. 777.

The Perception of Light and Colour.

By F. W. Edridge-Green, M.D., F.R.C.S.

The eye has often been compared to a camera, but it is really a complete photographic apparatus.

The retina, which is the membrane situated at the back of the eye, corresponds to the sensitive plate, upon which images of external objects are focussed. The sensitive layer of the retina contains two sets of elements, which are called from their shape rods and cones. The rods contain a purple substance which is very sensitive to light, and which is called the visual purple. The part of the eye, namely the centre, which possesses the best vision contains only cones, and external to this there is one cone with a ring of rods round it, and then one cone with two rings of rods, and so on, the number of rods increasing as we get to the outer part of the eye. The explanation which I have given of vision is as follows. I assume that the cones are insensitive to light, but sensitive to chemical changes in the visual purple. Light falling upon the retina liberates the visual purple from the rods, and it is diffused into the centre and other parts of the retina. The decomposition of the visual purple by light chemically stimulates the ends of the cones, and a visual impulse is set up which is conveyed through the optic nerve fibres to the brain. It will be seen that there are three distinct retinal processes—diffusion of the visual purple, decomposition of the visual purple by light, stimulation of the ends of the cones by the decomposition products of the visual purple. There is evidence of these three processes.

I assume that the visual impulses caused by the different rays of light differ in character, just as the rays of light differ in wave-length. Then in the impulse itself we have the physiological basis of light, and in the quality of the impulse the physiological basis of colour. I have assumed that the quality of the impulse is perceived by a special perceptive centre in the brain within the power of perceiving differences possessed by that centre or portions of that centre.

It will be noticed that the central portion of the eye, which possesses the most distinct vision, contains only cones, and is therefore blind until the visual purple has been diffused into it. The following simple experiments can be tried by the reader.

If we look at two small isolated stars of equal magnitude either may be made to disappear by looking fixedly at it, whilst the other remains conspicuously visible. I find that the phenomenon is most marked on a dark night, and when the star looked at is in a portion of the sky comparatively free from other stars, and when only one eye is used. On a very dark night a considerable number of small stars, occupying the centre of the field of vision, may be made to disappear whilst stars occupying other areas of the field of vision are plainly visible. Other lights or objects, when small and with dark surroundings, as, for instance, pieces of white cardboard on black velvet, may be made to disappear in a similar manner. No change can be observed if a very bright light, a group of stars, or a uniformly illuminated surface, be made the subject of the experiment. If we look at an illuminated object through a pin-hole in a piece of black velvet, we find that unless it be very bright it will not be visible at all. On moving the eye so that the image does not fall on the centre of the retina, the object appears brighter.

We must assume that the visual centre was developed first, and that at one time in past ages all objects appeared without colour as in a photograph. When the colour-perceiving centre was first developed, the rays of light differing most in wave-length were the first to be distinguished, and so the spectrum appeared nearly all grey or neutral, but with a tinge of red at one end and a tinge of violet at the other. As more and more cells were added to the centre it was not necessary that the rays should differ so much in refrangibility before a difference was seen, and so the red and violet gradually invaded the grey or neutral band, until at a certain point they met in the centre of the spectrum. Such cases are called "dichromics."

It will be seen that the term dichromic vision describes and includes all such cases because they only see two definite colours (red and violet). All these persons have a perception of light similar to the normal sighted, but there is a complicating factor which may be present, that is more or less shortening of one or both ends of the spectrum. This condition may be present with otherwise normal colour vision. The rays in the shortened portion are either not seen at all or are seen very imperfectly, and so a person of this kind might look at a bright red light and declare that there was no light there. The dichromic with an unshortened spectrum corresponds to the so-called green-blind and the dichromic with shortening of the spectrum to the so-called red-blind. There are innumerable varieties connecting the two, which are inexplicable on the older theories of colour vision. When there is shortening of the spectrum there is also light loss, but when it is of normal length and brightness this is not the case.

It is evident that we are dealing with two distinct conditions. All who have had practical acquaintance with the subject of colour-blindness are aware that all dichromics (so-called red-green-blinds) are not equally colour-blind. One dichromic will put a very full red and green together, but another will object to this, but will put together as a match a red and green occupying a relatively nearer position in the spectrum. The dichromic with the smallest neutral band in the centre of the spectrum, separating the two colours red and violet, has the best colour perception. This it will be seen is a prediction from the theory, and is inexplicable on any other. A dichromic with the smallest neutral band is very difficult to detect with any of the usual tests, and will generally pass them with ease. The reason of this is that a dichromic of this kind sees about six distinct differences in the spectrum, he sees green as a lighter and greyer colour than red, and distinguishes between them, just as a normal-sighted person distinguishes between bluish-greens and blues. This is how the colour-blind match wools. The dichromic are therefore those who see two true colours and grey. They regard red, orange, yellow, and half of the green as one colour: the other half of the green, blue, and violet as the other. The presence of a neutral band causes the colours corresponding to this portion of the spectrum to be seen as grey. Therefore, the larger the neutral band the more colours will be classed as grey. If the rays which fall within one colour of the dichromic be mixed with those which fall within the other, grey will be the result. Therefore violet and red, instead of making a purple to the dichromic, make a grey which is indistinguishable to them from the grey made by blue and green.

The next stage of evolution of the colour sense is when the colour-perceiving centre is sufficiently developed to distinguish three main colours in the spectrum. The third colour (green) appears in the centre of spectrum, that is at the third point of greatest difference of refrangibility of the rays. In accordance with the prediction of the theory I found a considerable number of persons who saw the spectrum in this way, about 1·5 per cent of men. The trichromic see three main colours in the spectrum: red, green, and violet. They usually describe the spectrum as consisting of red, red-green, green, green-violet, and violet. They do not see yellow and

blue as distinct colours, and are therefore in continual difficulty over them. There are very few of the tests in general use which can detect them, especially if names be not used. They will usually pass a matching test with ease. An examination with the spectrum shows that their colour perception is less than the normal in every part, though the curve has the same general shape. The three trichromics described in my recent paper on 'Observations on Hue Perception'* each saw ten consecutive monochromatic patches in the spectrum instead of the eighteen or nineteen seen by those who see six colours in the spectrum. It is easy to show that the trichromic are dangerously colour-blind. They will mark out with the spectral apparatus a patch containing greenish-yellow, yellow, and orange-yellow, and declare that it is absolutely monochromatic. When tested with coloured lights, they find great difficulty with yellow and blue. Yellow is continually called red or green.

There are several other degrees of colour-perception, and it may be well to say a word or two about them, though I class all above the trichromic with the normal-sighted for practical purposes, as they are not dangerously colour-blind, and can always distinguish signal-lights correctly.

In the next stage of evolution four colours are seen in the spectrum, and the fourth colour appears at the fourth point of greatest difference of refrangibility, namely at the orange-yellow of the hexachromic or six-unit people; these persons I have designated tetrachromic, because they see four distinct colours in the spectrum, that is red, yellow, green, and violet. They do not see blue as a definite colour, and are continually classing blues with greens: they usually prefer to call blue purplish-green. In the next stage in evolution there appeared those who see five colours in the spectrum—red, yellow, green, blue, and violet, blue being now recognized as a definite colour; these are the pentachromic group. These people pass all the tests in general use with ease; they however have a definitely diminished colour perception compared with the normal or those who see six colours in the spectrum. They mark out in the spectrum only fifteen monochromaitc patches instead of eighteen. They cannot see orange as a definite colour; for instance they can never tell whether a strontium light, which is red, or a calcium light, which is orange, is being shown them. In the next stage of evolution orange is recognized as a definite colour, and thus we get the hexachromic or normal group, and, as we should theoretically expect, the yellow of the pentachromic is now split up into two colours, orange and yellow.

In the last stage of evolution which we appear to have reached are those who see seven colours in the spectrum and the additional one is called indigo. These constitute the heptachromic group, and this seventh colour appears at the exact point which it should appear according to my theory, namely between the blue and violet. Persons belonging to this class have a marvellous colour perception and memory for colours. They will indicate a certain shade of colour in the spectrum, and then next day will be able to put the pointer at precisely the same point, a feat which is quite impossible to the ordinary normal-sighted person. They see a greater number of monochromatic patches in the spectrum than the hexachromic, but the curve has the same form. The marking out of the heptachromic does not appear correct to those who see six colours; for instance, the blue appears to invade the green, and the indigo does not appear a definite colour at all. If, however, we bisect the blue of the seven-colour man and then bisect his indigo, on joining the centres we get the blue of the six-colour man, showing most definitely that the blue has been split up into two fresh colours.

It will be noticed that there is room for much further evolution, and we could go on splitting up the spectrum indefinitely if only we had the power to distinguish these finer differences; but as a matter of fact I have never met

* *Trans. Ophth. Soc.*, 1907

with a man who could see more than twenty-nine monochromatic patches in the spectrum, and there are really millions, though by monochromatic patches I do not mean twenty-nine separate colours.

The first requirement of a test for colour-blindness is that colour names shall be used, and that the person to be examined and the examiner should employ and understand the use of the colour-names: red, yellow, green, and blue. I can say in the most emphatic manner that no test which ignores names can be efficient. I predicted that if colour-names were ignored in the Board of Trade tests normal-sighted persons would be rejected, and this prediction was fulfilled: of those who appealed from the decision of the Board of Trade over 38 per cent in one year and more than 42 per cent in another were found to have been rejected wrongly.

Nothing shows the value of colour names better than an examination with my lantern of certain educated colour-blind persons who have just passed several of the well-known tests with the greatest ease. They call red "green" and green "red," and apply either term to yellow, thus not only proving their colour-blindness, but showing how absolutely unfit they are to act as engine-drivers or look-outs. An engine-driver has to name a coloured light when he sees it, not to match it. The sailor has rarely opportunities of comparing lights. Such men have to say to themselves "This is a red light, therefore there is danger," and this is practically the same as if they had made the observation out loud. Several artists have remarked to me that they pay far more attention to shade than colour, and that the confusion colours of the wool test were more like the test green than those which are supposed to be picked out by normal-sighted persons. A very simple illustration may serve to make my point quite clear. Let it be supposed that I wish a man or a child to separate a roomful of people into men and women. I take him to the room and say, "Now I want you to separate these persons. I want you to put all who look alike in one class, and the remainder in the other." When I return I find that he has put all the big people in one class, and the small people in the other. If I then say, "You have classified them wrongly. I wanted you to put the men in one class and the women in the other," he could reply, "Then why did you not tell me that you wanted me to separate them into men and women?"

The principal tests I use are three in number: (1) Lantern Test. (2) Classification Test. (3) Spectrum Test.

It will be noted from this short account of the physiology of vision that the nature of the illuminant which is used for lighting a room is of very great importance. The distribution and arrangement of the illuminant are of equal importance.

I think that it is probable that the artificial illuminant which most resembles sunlight in its composition will be found to be most beneficial for the eyes; but this is a point which still remains to be settled.

An Interesting Case of Colour Blindness.

An interesting case of colour blindness, in which loss of colour was apparently experienced without great loss of perception of light, is described by Dr. Edridge-Green in his book on this subject. A captain was accustomed to work at embroidery in his leisure time at sea, and was in the habit of taxing his eyes in the twilight by working on without a proper light. One day, while so engaged, his sense of colour almost completely disappeared, the only colour that he could afterwards still clearly recognize being blue. Yet his vision does not seem to have been seriously affected in other respects for he continued his vocation for some time afterwards.

The Measurement of the Relation between Daylight Illumination of Rooms and Sky Brightness.

By Percy J. Waldram, F.S.I.

The daylight illumination of any point in a room may be considered as being a proportion of the illumination which it could obtain from the whole luminous sky above the horizon if the walls, ceiling, and all obstructions were removed. This proportion of the total daylight is obtained through the windows, and generally consists partly of direct rays from the sky and partly of reflected rays from walls, buildings, road surfaces, &c., the whole being reflected and counter-reflected from the walls, ceiling, and floor of the room.

The amount of daylight illumination at any point in a room depends partly upon fixed conditions and partly upon the variable brightness of the sky at any moment. The fixed conditions are the size, shape, position, and glazing of the windows, the extent to which their view of clear sky is obscured, the reflection co-efficients of the obstructions and of the walls, ceiling, and floor of the room itself. The combined effect of all these fixed conditions is, however, for all practical purposes, the same whatever the sky brightness, so that the proportion of the total flux of light from the sky received by any point in a room is practically the same at any time between sunrise and sunset from June to December, with the obvious exceptions of such times when the room may be receiving direct rays of sunlight or directly reflected rays. This proportion may be termed the "window efficiency," and may be measured for any point in a room or may be averaged over the whole floor area at table height or any other height.

The average "window efficiency" of any room may thus be defined as the fixed relation between its average interior illumination (a), and the sky brightness (b) or the ratio $\frac{a}{b}$.

The proportion of daylight illumination enjoyed by interiors is very much smaller than is usually supposed. If the illumination of a piece of white paper be measured first when the paper is placed on a table in the middle of an average room, and then when placed on a table outdoors in an open space, one finds a difference of say 1,000 to 1 in favour of the latter position. To any one considering the matter for the first time such a difference seems impossible; most people looking at the piece of paper in the two positions would estimate the respective illuminations at say 2 or 3 to 1, and would consider even 100 to 1 ridiculous. The difference, however, does not seem so startling when it is remembered that under the same conditions a photograph of any outside view might require say one-fifth of a second, whilst the necessary exposure for an interior might well be, say, five minutes with the same stop, a difference of 1,500 to 1.

The eye does not indicate these very large variations of diffused daylight illumination because it is able to adapt itself to them without sensible effort or strain; but the lower limits at which reading, writing, drawing, and indoor industrial operations become trying or impossible, are more sharply defined. One can as easily read out of doors under a diffused daylight illumination of say 800 candle-feet, as indoors at say 2 candle-feet, whereas at 1·5 candle-feet reading is not quite so easy, at 0·5 candle-feet it is somewhat difficult, and at below 0·1 candle-feet it soon becomes impossible.

But even in this matter of defining the lower limits at which it is advisable to supplement daylight by artificial illumination the eye is not to be trusted. So long as the illumination is decreased evenly and slowly, as in the waning light of a winter afternoon, the eye will loyally attempt to adapt itself to the more onerous conditions, and will not infrequently induce one

to continue reading or writing by daylight, long after the time when the assistance of artificial light should have been resorted to. By the time the eye finds the strain unbearable, the mischief has been done.

The danger of this to the delicate eyes of school-children is only too obvious. A teacher may quite unconsciously strain constantly and seriously during the winter months the eyes of young pupils by a very natural disinclination to interrupt work to turn on artificial light until its necessity is apparent to his own eyes, which would be naturally trained by years of reading, or until a child acutally complains. It would cost very little to provide every public elementary school with a simple illuminometer, which would enable the head master to note a point of minimum daylight illumination, fixed by the medical inspector, at which artificial light would be necessary in the worst-lighted classroom. If this were done, not only would one of the greatest and most subtle dangers to eye-strain in children be removed, but means would be placed in the hands of head masters which would enable them to co-operate intelligently in studying and remedying the many defective features of artificial lighting in schools.

To measure the illumination, daylight or artificial, in candle-feet at any point in a room is the simplest of operations, consisting with an ordinary Trotter photometer of pressing a button and turning a handle until the illumination on two screens becomes identical, a pointer in the instrument automatically recording the illumination in candle-feet.

To ascertain the "window efficiency" of a room by comparing an average of such daylight measurements with a simultaneous measurement of sky brightness is, however, not quite so simple.

The extent of outside illumination is affected largely by surroundings, and even if one had an instrument capable of covering the wide range between inside and outside illumination it would be impossible to compare the window efficiency of one room with another unless all the respective outside illuminations were measured with an absolutely clear horizon. This, of course, would be a practical impossibility, and our photometer must therefore be capable of measuring the brightness of a portion of the zenith sky, and must take identical readings of it from the bottom of a deep light well or from the top of a roof.

Acting upon a suggestion made by Mr. A. P. Trotter, the author has found no difficulty in doing this with an ordinary instrument in the following manner.

The total daylight illumination falling upon the screen of an illumination photometer, placed horizontally with an uninterrupted horizontal horizon in the centre of an open plane, may be considered as the total flux of light coming from the interior of a hemispherical luminous sky surface of radius R; and on the cloudy days when the daylight illumination of interiors becomes important, this luminous surface may be considered as being for all practical purposes uniformly bright.

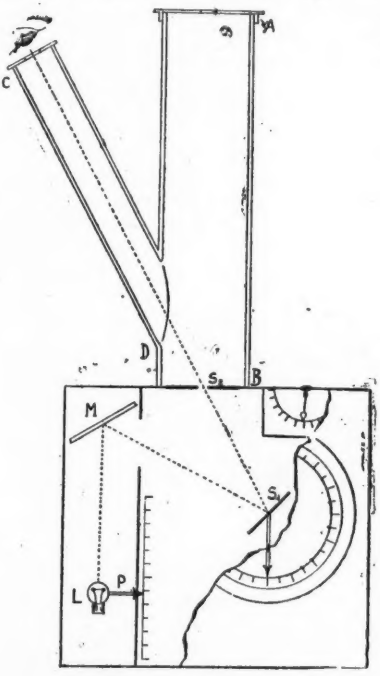
The illumination (I) on a horizontal surface, would, under those conditions be represented by the area of the hemispherical surface in feet multiplied by its brightness per square foot (B), and divided by R^2 or

$$(1) \quad . \quad . \quad . \quad I = B \times \frac{2\pi R^2}{R^2}$$

$$(2) \quad . \quad . \quad . \quad B = \frac{I}{2\pi}$$

The radius of the sky thus disappears from the problem, because obviously the illumination of the horizontal photometer screen would be the same whether we measure the beams of light causing it at a radius of 10 miles or of 10 inches; their effect on the screen falling off in exactly the same proportion as their area increases. We can therefore assume any convenient value we like for R so long as we measure the illumination on a hemisphere of that radius. Also we need not trouble about the whole of the luminous hemisphere so long as we can measure any definite fraction of it. For practical measurements we can replace the actual

sky by a small light-tight hemisphere of any convenient radius, pierced by a hole having an area which is a certain definite fraction of the surface of that hemisphere. The amount of illumination falling on the photometric screen from the portion of sky visible at the screen through that hole bears the same proportion to the total illumination which would fall upon an uncovered screen as the area of the hole bears to the total surface of the hemisphere. The measured brilliancy of the hole in candles per square foot as seen from the photometric screen $\times 2\pi \div r^2$ gives the same figure for the sky brightness



in candles per square foot whatever radius (r) it may be measured on. It is, of course, unnecessary to construct an entire hemisphere, a tube of a length equal to the proposed radius giving exactly the same result.

Using an ordinary Trotter photometer with a yellow or orange screen outside, and a white screen inside (*vide Illuminating Engineer*, vol. i. No. 6, p. 502) one can obtain excellent results by means of an apparatus made out of the cardboard capped tubes used for conveying drawings.

A 10-in. length of tube A B is cut very exactly with a sharp penknife, a short side inlet tube C D for viewing the top slide is neatly fitted to one side at such an angle that when fitted over the outer screen S^2 its axis is in line with the slot and the index pointers of the inner screen, S^1. The whole is made perfectly light-tight and blackened inside, and can be held tightly on to the instrument by means of elastic, looped round the larger tube, passing round the photometer and looped over the side tube, the joint at B being made light-tight, if necessary, with a narrow black velvet washer. On the top of A B is placed the ordinary cardboard cap of the tube, in the centre of which a hole 1·55-in. diameter is neatly cut, giving an aperture area of 1·884 square inches, or 3 to 1000 of the area (628 square inches) of a 10-in. hemisphere. Holes representing areas of 2-1000, 1-1000, 1-2000, &c., can be cut out of thin postcards, and fitted concentrically inside the cap as required, in order to get readings which will be within the range of the instrument with varying degrees of sky brightness, in the same way that a photographer uses a different stop in the lens of his camera to suit varying conditions. The minute difference in the diameter between these stops necessitates very careful setting out and cutting; but with care they can be cut to give readings correct to 0·01 candle-feet exactly in proportion to their areas. They can, of course, be replaced by a suitable iris diaphragm to facilitate the working, but there is less liability to error with fixed stops. Although the author would not advocate the general use of such a home-made appliance, it is nevertheless capable of a very large amount of good work. It gives absolutely identical readings when held (1) outside a window, (2) from the top of a roof, or (3) from the bottom of very deep narrow areas. After a little practice one can readily select for any sky say three or four stops within the range of the instrument, say 1-500, 1-1000, and 1-2000, and the

proportion which should obviously exist between the resulting readings acts as a ready check on their accuracy. An ordinary sky reading might be say 0·52 candle-feet with a 1-1000 stop. If the 1-2000 stop be inserted 0·26 should be recorded and 1·04 with a 1-5000 stop.

The area of a 1-1000 stop being 0·63 sq. in., and the distance from the photometer screen to the aperture 10 in. the sky brightness in candle-power per square foot (B) as measured at the aperture would be :—

$$B = 0{\cdot}52 \times \frac{144}{{\cdot}63} \times \frac{10^2}{12^2} = 82{\cdot}5 \text{ candles}$$

per square foot.

Or this could be obtained by simply dividing the reduced reading by 2π as equation (2)

$$B = \frac{520}{2\pi} = 82{\cdot}5 \text{ as before.}$$

For measuring the window efficiency of a room it is not necessary to reduce the readings of outside illumination to terms of sky brightness, although this is desirable for purposes of record. The inside illumination in candle-feet is simply compared direct with the corrected reading in candle-feet of the outside illumination. If the outside reading be, say 0·7 candle-feet, with a 1-1,000 stop, and the average inside reading be 0·5 candle-feet, then the room has an average efficiency of $\frac{0{\cdot}5}{700}$ or $\frac{1}{1400}$.

It should be noted that the accuracy of photometric measurements of window efficiency is *not* affected by the calibration of the instrument; nor does any drop in the efficiency of the photometer standard lamp, or in the voltage of its battery, make the slightest practical difference, as the indoor and outdoor readings are necessarily taken as nearly simultaneously as possible. The name of the makers of the Trotter photometer (Messrs. Everett, Edgcumbe & Co.), would of course be ample guarantee of correct calibration, but it is satisfactory to remember that efficiency readings are independent of any deterioration in the lamp or battery.

If all readings of sky brightness be carefully recorded, with dates, times, class of sky, &c., very valuable information is obtained as to average sky brightness, of which no complete records for English towns have yet been published. The author has in preparation a complete year's record for London, based on daily observations taken at 9.30 A.M., 12 noon, and 4 P.M., and also upon observations taken every hour from sunrise to sunset upon typical days in each month. But the daily duration of natural light is so important a consideration with all lighting problems that there is need for records more exact, continuous, and authoritative than any individual statistics, however carefully compiled, can possibly be.

In recording isolated measurements of sky brightness on given dates and times it is necessary to define, at least roughly, the state of the sky if the record is to be of any value, in estimating continuous records.

The following classification was adopted by Dr. Basquin for a very large number of sky brightness measurements taken in Chicago (*vide Illuminating Engineer* of New York, vol. i. No. 10) :

Class 1. Clouds, no blue sky, no sun, storm present or near.

Class 2. Overcast, no blue.

Class 3. Clouds predominating, generally cumulus.

Class 4. Blue predominating, clouds generally cirrus.

Class 5. Cloudless, either clear blue or hazy.

This is the order in which nine people out of ten who were not expert photographers would arrange the different kinds of sky if asked to place them in order of brightness. As a matter of fact, with the exception of class 1 the correct order is exactly reversed, the relative mean brightness being in round figures :—

Class 1.—200 Candles per square foot
,, 5.—300 ,, ,, ,, ,,
,, 4.—430 ,, ,, ,, ,,
,, 3.—560 ,, ,, ,, ,,
,, 2.—620 ,, ,, ,, ,,

These values are, of course, only relative, and vary for each class of sky according to the season and the time of day. They are instructive, however,

as showing the great and unexpected difference which can honestly exist between the observations of the daylight illumination of a room taken at similar times on consecutive days. Very few people would expect to find the illumination increased by clouds, scarcely any one would expect the illumination from a cloudy sky to be more than double that from a clear blue sky.

For the estimation of the daylight illumination of interiors, however, the eye is at best a measuring instrument of ridiculous inaccuracy, far more liable to record insignificant factors than the total result. The exact measurement of those essential factors which affect gas and electric light bills and their estimation by the untrained eye are frequently two very different things; and generally speaking there is more difference between the apparent and the real daylight illumination of a room than there is between a pencil landscape sketch and a trigonometrical survey.

Many people when estimating the brightness of a room unconsciously base their estimate simply upon the effect, pleasant or otherwise, which the wall-paper has on them. Wall-paper certainly affects interior illumination, but it is most difficult to estimate correctly even the relative advantages of different colours and shades—light red, for instance, gives apparently quite as light an effect as light buff or pale grey, whereas the two latter really reflect nearly four times as much light.

The view from the windows is another criterion frequently applied most erroneously. Hard-headed business men, selecting town offices with a view to a good light, will stand in the middle of empty rooms and really decide upon what they see at a distance outside the middle (not the top) of the windows, and not upon the light that is really coming in at desk height at all. Offices with single large low windows facing a high new wall will sometimes let whilst others with high windows facing a low old wall will remain empty; because there is, according to prospective tenants, "no comparison between them in point of lightness"; whereas the probability is that the bill for gas or electricity during ordinary office hours would be quite 20 per cent less in the latter offices.

The measurement of the only true criterion of daylight illumination, *i.e.*, window efficiency, is by the means described, effected for any room at any time except when the sun is directly shining or reflected into it.

But before the window efficiency of different rooms can be exactly compared it is necessary that the factors affecting efficiency are either identical or are reduced to a common standard. All rooms have not the same wall and ceiling papers, proportions vary; window glass and its relative cleanliness, or rather relative dirtiness, the angles of obstructed horizon, and all other essential factors must, for real comparison, be standardized by comparison with white walls and ceilings, clean clear glass, unobstructed horizon, &c. Fortunately it is possible to reproduce the conditions of actual rooms in small models and obtain the same results by identical measurements, and in such models the various effects produced by variations in essential conditions can be studied at no great cost. For instance, a model can be temporarily papered with samples of twenty different wall-papers, and their different effects noted in less time than an actual room can be temporarily hung with two—every possible condition of obscured horizon can be built up of sheets of paper or cardboard, having reflection co-efficients identical with those of all known building materials; the relative lighting capacity of every square foot of wall surface can be separately found for every degree of obstruction and for any given distance back from the window wall; and, in fact, every possible condition can be reproduced, measured, and standardized, so that the essential conditions for any given window efficiency can be accurately predetermined by simple calculation. The average number of hours during which natural light must be supplemented by artificial light over any given period, say from 9 A.M. to 6 P.M., can, of course, be directly obtained for any given window efficiency from yearly tables of average sky brightness.

Illumination in Emergencies.

THE recent strike of the employees of electrical supply companies in Paris furnished an example, on an exceptionally great scale, of the inconvenience attending the sudden deprivation of the regular method of lighting. With dramatic suddenness the lights in the theatres went out, and the audiences dispersed; while in some of the restaurants a number of customers are said to have availed themselves of the darkness to escape without paying their bills.

Under the circumstances a sudden call upon the available supplies of candles in neighbouring shops was inevitable. The candle has come to be looked upon as a mainstay in such cases, simply because, although hardly yielding sufficient light for most ordinary purposes, it is self-contained, and can be put in use at short notice. It has, indeed, been shrewdly remarked that, had the candle been invented for the first time in the present age of illumination by the aid of transmitted energy, it would have been hailed with enthusiasm as a magnificent discovery. At the same time the candle has many obvious drawbacks even for emergency-lighting, and it seems to be now desirable to provide for such accidents more perfectly than has been hitherto attempted. Already it has become customary in the case of important buildings to specify that two alternative systems of lighting, such as gas and electricity, must be provided, so as to avoid the inconvenience of a breakdown of either.

After the example of Paris, however, a strike affecting *both* systems of lighting does not seem inconceivable. Moreover supply companies, particularly electrical ones, are naturally not overanxious to assist consumers who merely propose to utilize them as a stand-by in an emergency. Some system entirely independent of outside supply seems needed to ensure the most perfect safety from all disturbances.

In the case of electricity there is, unfortunately, no practical method of storing, analogous to liquid acetylene for instance, unless indeed accumulators be so considered. There is on record a case of a theatre-manager who had taken a new theatre, and billed a play to appear on a certain night. When the date arrived it transpired that the electric supply company was not ready, but the enterprising manager ran the lighting for the time being from an imported battery of charged accumulators.

Permanent independence, however, can only be achieved by a private installation, and this plan naturally commends itself to many large restaurants and theatres. Petrol-air gas and acetylene offer an alternative method of private supply. Oil-lighting, of course, has long been recognised as a stand-by, and has many advantages if only the possibility of an emergency is kept in mind, and the lamps are properly attended to.

Liquid acetylene, on account of its ease of transport, now merits consideration in an emergency, while it is claimed for some of the various qualities of liquid gas now coming into use, that they can be connected and used with an ordinary system of gas-piping should an emergency occur.

A Metallic Filament Glow-Lamp for High Voltage and Low Candle-power.

By B. Duschnitz.

As is well known, it is only quite recently that it has been found possible to manufacture metallic filament glow-lamps for high voltages. This feat has also only been accomplished as yet by a few firms. At the present time the majority of manufacturers are content to make lamps for a maximum pressure of 130 volts.

Even in cases in which their efforts have been successful, the makers have been obliged to grapple with tremendous difficulties in manufacturing such lamps, and have only done so in order to meet the demands of consumers supplied with a pressure of 220 volts, who disliked burning the lamps in series.

However, as we know, the Auer Gesellschaft have met this pressing demand, to the extent of already manufacturing 220 volt 50 H.K. lamps. But the filament utilized in these lamps is about 1,030 mm. long, and about 0·03 mm. in diameter.

A second example is afforded by the "Just" Wolfram 220 volts 50 H.K. lamp. In this case six U-shaped filaments are mounted in series, each of these being 80 mm. long, thus yielding a total length of filament of 960 mm.

When we recall what immense difficulties were at first experienced in making even a 110 volt 25 H.K. tantalum lamp (having a filament 650 mm. long and 0·05 mm. in diameter), with the ordinary standard Edison cap, we can readily concede the difficulty of mounting filaments 960 or 1,030 mm. long in a bulb, the cap of which must be no bigger than that of the tantalum lamp.

That the fragility of filaments only 0·03 mm. in diameter leads to an immense number of breakages in manufacture is easy to understand. And how easily such filaments are ruptured in use and transport! The writer himself, a short time ago, was present when a 50 H.K. 220 volts osram lamp was merely carried—quite carefully—from one table to another; yet the filament broke. Such cases must occasionally have come within the observation of any one who has had much experience of high voltage metallic filament lamps, especially those of inferior make.

Another very noticeable quality of metallic filament lamps is their difference in resistance when switched on and when in the cold state. That this difference is anything but trifling will be understood from the following details.

A portion of a tantalum filament, 1 mm. long and 1 sq. mm. in cross section, has a resistance of 0·17 ohms in the cold state, but this increases to 0·83 ohms when the lamp is burning.

Again, a piece of osmium filament, 1 mm. long and 1 sq. mm. in cross section, has a resistance of about 0·095 ohms at 20 degrees Centigrade, but at the ordinary temperature of incandescence of the lamp this rises to 0·798 ohms. In the case of other metals we obtain very similar results. On the average the resistance of a metallic filament in the cold state becomes multiplied eight times when the lamp is actually burning, and therefore the initial value of the current taken by the lamp may be eight times its normal value.

One not infrequently finds that a metallic filament burns out the instant it is switched on, simply on account of this high initial current; naturally, too, the tendency to failure in this way is more marked the thinner the filament. In order to provide against this difficulty the makers of high voltage lamps are abandoning the attempt to make these lamps with an efficiency of 1 watt per H.K., and revert to about 1·5 watts per H.K., in order that the filament may be stout enough to stand the initial rush of current without fusing.

Now the great majority of electric installations date from the time when

carbon filament glow-lamps held undisputed sway, and are adapted for the use of 16 candle-power lamps. The consumers would in most cases gladly avail themselves of the metallic filament lamps in order to reduce the current consumed for the same or a somewhat greater amount of light than they had previously at their disposal.

When, however, we reflect that a metallic filament 220 volt 50 H.K. lamp burning at, say, 1·25 watts per H.K., consumes 62·5 watts, it becomes clear that the consumer who substitutes such a lamp for an ordinary carbon filament 16 candle-power lamp, consuming 56 watts at 3·5 watts per H.K., gains nothing whatever as regards reduction of current. On the contrary, he would actually have to consume 62·5–56, *i.e.*, 6·5 watts per lamp more than before.



FIG. 1.

Granted, even, that 220 volt 40 H.K. were available, the initial costs of such lamps and the fragility of the long filament would militate against their general acceptability.

All this, however, is only intended to apply to the purely metallic filament lamps, *i.e.*, such lamps as are not provided with any additional accessory apparatus in series with the metallic filament. The author has recently had the opportunity of studying a new type of combination-lamp invented by Schäffer of Berlin, and manufactured by Messrs. Köhler, Spiller & Co. of Hamburg.

The general nature of this so-called "Econo-Metallic Filament Lamp" will be understood from Fig. 1.

In this case the bulb of the lamp does not terminate in the usual Edison cap, but is attached to a projecting ring and metal gallery, in the interior of which is mounted a smaller evacuated glass bulb containing a spiral, triply wound carbon filament. The small vessel is melted on to the main bulb, containing the usual metallic filament, to which the carbon filament in the small bulb is connected in series, serving the purpose of a ballast-resistance.

The resistance of the carbon filament is so chosen that it consumes 80 volts, leaving 140 volts to be consumed in the metallic filament. The latter is arranged to run at an efficiency of 1 watt per H.K., when it receives 130 volts; at 140 volts the consumption is about 0·95 watts per H.K. The carbon filament, however, is also rendered incandescent, contributing about 1·5 H.K., and the total light yielded by both filaments amounts to about 30 H.K. The current taken by the lamp as a whole is 0·21 ampere, the power consumed being therefore $220 \times 0{\cdot}21 = 46{\cdot}2$ watts. This corresponds to a specific consumption of $\frac{46{\cdot}2}{30} = 1.54$ watts per H.K.

The Schäffer lamp seems, therefore, well adapted to replace the 16 candle-power carbon lamp on 220 volt circuits. For by using such a lamp we save $56 - 46{\cdot}2 = 9{\cdot}8$ watts, and gain $30 - 16 = 14$ candle-power (H.K.).

Moreover, as the metallic filament need only be about 500 mm. long, the risk of breakage is very much less than in the case of the ordinary high voltage lamps requiring a 1,000 mm. filament.

But special attention may be drawn to a particularly interesting characteristic of the lamp arising from the use of a carbon and metallic filament in series with one another. As a result the initial current taken by the lamp is but twice its final value, as opposed to eight times in the case of metallic filaments pure and simple. The explanation of the above property lies, of course, in the fact that the temperature coefficient of the metallic filament is negative, while that of the carbon filament is positive, so that a certain compensating effect occurs. This may be expected to have a favourable influence on the life of the lamps.

Some Examples of Practical Work in Illuminating Engineering.

It is becoming more and more generally recognized that supply companies will be obliged, in the future, to take a much more immediate and organized interest in the conditions of illumination enjoyed by their customers than in the past. We notice in some recent numbers of *The Electrical World* and *The Electrical Review* of New York some remarks by Mr. A. J. Marshall dealing with this subject. Mr. Marshall remarks at the outset that it is obviously in the interest of the company to see that their customers use their lights properly, to win their confidence as regards the methods of lighting they suggest, and to assure them that their interests are properly protected. If this is not done it may safely be assumed that in a great many cases the company is more or less directly blamed for the large bills and inadequate lighting that naturally follow.

Mr. Marshall suggests that this difficulty is to be met by employing canvassers who have a really adequate knowledge of illumination, and can assist the company's interests by attending to those of the consumer. The salaries usually paid are hardly such as to secure men with these qualifications, but Mr. Marshall considers that it would amply repay companies to afford the extra expense entailed.

Proceeding further, he suggests that illumination ought to be the subject of systematic inspection. Inspection is obligatory in the case of electric wiring, for instance, and a central station does not, as a rule, connect up to the consumers' premises without receiving an assurance that all is satisfactory. Why, therefore, should not the conditions of illumination be subject to some such similar scrutiny? Naturally such a course would require no little diplomacy, and Mr. Marshall hardly suggests that an electric company would go the length of refusing to supply in the event of the scheme of illumination not being considered satisfactory. But a regular and systematic inspection of premises previous to connecting up would enable the engineer to suggest means by which the lighting might be easily improved, and might save much subsequent dissatisfaction. It need not be said that in such matters the company should be prepared to act in co-operation with the contractor, but it is only reasonable that they should take an interest in matters in which both parties are so vitally interested; and, wisely carried out, such an arrangement would be to their mutual benefit.

A step further on the part of the company would be the establishment of a definite department of illuminating engineering organized for the purpose of assisting customers, and presided and assisted by competent illuminating engineers. In this connexion it is something of a coincidence that we have received a letter from the Edison Electric Illuminating Company of Boston explaining the steps they are taking in this very direction. The Company is opening a department that will be known as the Division of Commercial Illuminating Engineering, which will place the experience of Dr. Louis Bell at the service of consumers who require advice on the arrangement of their lighting units, and the department will maintain a staff of assistants for the purpose.

Accompanying the letter referred to the Company send us a series of pamphlets recently issued by them announcing this step. Although the Boston and other companies have previously sought to advise consumers in this way, this is probably the first occasion on which an electric supply company have organized a definite department to deal specifically with problems of this nature for the con-

sumer's benefit, and the results already recorded are said to have amply proved the value of its existence.

It may also be recalled that the ILLUMINATING ENGINEERING BUREAU of New York deals exclusively with problems of this class, and that the GENERAL ELECTRIC CO. in Schenectady have also for some time maintained an organized department of illuminating engineering.

Another aspect of this question is the progressive education of the public in these matters which is now taking place, and which in itself seems likely to render arrangements of the nature described on the part of supply companies almost obligatory. The August leaflet of the HOLOPHANE CO. affords interesting reading in this respect, and gives some idea of the educational work among the general public that is constantly taking place in the United States. We notice, for instance, a description of the popular demonstrations being undertaken by Mr. C. A. Howe. At the meeting for business men, organized in co-operation with the Kankakee Electric Light Co., those present were invited to bring up any lighting problems they had experienced, and almost all joined in the discussion. Subsequently the entire audience visited several shops in the neighbourhood, in order to inspect illustrations of the principles just discussed. It is stated, indeed, that Mr. Howe has been invited to give a second lecture at the Women's Club in Kankakee, the subject being 'Economical House Lighting.' This, however, is said to be only one among a number of women's clubs, distributed in different parts of the country, that Mr. Howe has visited.

The Prevalence of Cataract Among Glass-Workers.

THERE is one section of the recently issued annual report of Dr. T. M. Legge, H.M. Medical Inspector of Factories, which is particularly interesting in view of the recent discussion by Dr. Schanz and Dr. Stockhausen, Dr. Voege, and others, upon the effect of ultra-violet rays upon the eye. According to some authorities the production of cataract may be at least partially due to the action of such rays, which have been proved to give rise to a certain turbidity of the eye lens, when present in large quantities; in particular it has been suggested that the exceptional prevalence of cataract among glassworkers might be explained in this way.

According to the report quoted, inquiry into the condition of the eyes of workers of glass in different parts of the country showed that persons continually exposed to incandescent molten glass and furnace-glare suffer from cataract more than ten times as frequently as other people, and the inspector, while abstaining from offering a definite opinion as to the explanation himself, mentions the suggestion as to the influence of ultra-violet light, and the possibility of using blue glasses as a preventive. He also points out significantly that "the combined knowledge of the physicist and physiologist is required to arrive at a conclusion on these points."

The problem in question is an excellent illustration of the value of co-operation of this nature, which *The Illuminating Engineer* has constantly advocated.

Dr. Schanz and Dr. Stockhausen, it will be remembered, have recently declared that ordinary glasses, and even those constructed of blue glass, fail to stop the ultra-violet rays of the most dangerous nature, and they therefore suggest the desirability of using a special "euphos" glass, which is completely opaque to the objectionable radiation.

If the prevalence of cataract among glassworkers is indeed actually due to the effect of these rays, such a glass might prove very useful; in any case it might enable experiments to be carried out with the object of definitely proving whether the objectionable physiological effects are due to the actinic rays or no.

The Production and Utilization of Light.

The Laws and Measurement of Radiation.

By Dr. C. V. Drysdale.

(*Continued from p.* 718.)

The majority of the accurate measurements on radiation, however, have been made with one of two electrical devices, the thermopile and the bolometer. Seebeck's discovery of the thermo-junction in 1821 and Nobili's pile made up of several bars of bismuth and antimony enclosed in a metal case which could be provided with a collecting cone (Fig. 6) led to Melloni's classic experiments in radiation, and the important investigations of Tyndall, to be referred to later. To Prof. C. V. Boys, however, we owe the extension of this principle to the production of one of the most sensitive means of detecting radiation extant—the radio-micrometer, or micro-radiometer. The principal defects of the ordinary thermopile and galvanometer combination lie in the high resistance, when connexions are included, the great heat capacity of the pile, and the thermal conductivity from the hot to the cold junction. In the radio-micrometer which is shown in Fig. 7 the junction and galvanometer are combined in a single instrument, which consists essentially of a d'Arsonval galvanometer, in which the moving coil is formed by a long narrow single

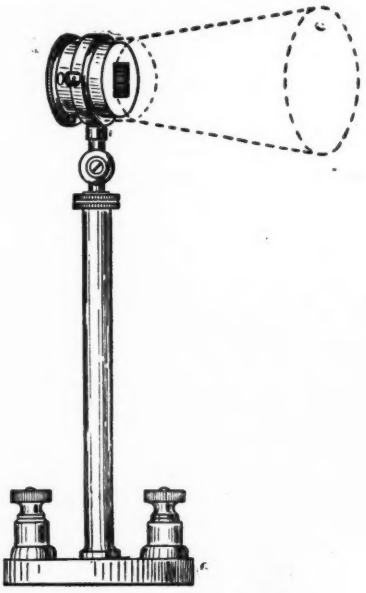


Fig. 6.—Nobili or Melloni Pile.

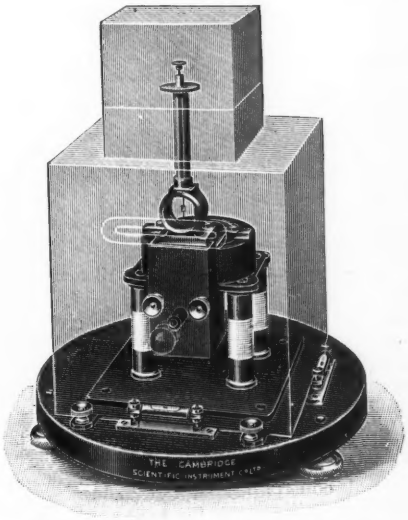


Fig. 7.—General View of Radio-Micrometer.

loop of copper wire (Fig. 8) at the bottom of which are soldered two minute rods, one of bismuth and tin, the other of bismuth and antimony. A small blackened silver plate is soldered to the lower ends of these rods, thus completing the circuit and receiving the radiation, which sets



FIG. 8.—Moving System of Radio-Micrometer.

up a thermo-E.M.F. in the circuit. The loop is simply suspended in the field of the magnet by a quartz fibre, thus securing the advantages of a very low resistance galvanometer without leads or metallic suspensions; and, consequently, a very small controlling torque is exercised. The sensitiveness of the instrument as ordinarily constructed is such that one watt at a distance of about 7 metres gives 1 mm. deflection at a metre distance, and its readings are rapid and definite, almost perfect damping being obtained by the magnetic action on the short-circuited coil.

An instrument which is also extremely sensitive, and which has been more used than the radio-micrometer is the bolometer. Although the principle of this instrument was discovered and employed by Svanberg in 1850* it was left for Langley in 1881† to develope it into a sensitive instrument, with which he conducted his famous researches on radiation in the spectrum. The original instrument of Svanberg is shown in Fig. 9, and was called by him a "galvanic differential galvanometer." It consisted simply of a flat spiral of silk-covered wire supported inside a hollow wooden cylinder. The rise of temperature due to radiation falling on the spiral was measured by the increase of its resistance, and he was able to measure a temperature difference of one-six-hundredth of a



FIG. 10.—Ångstrom's Pyrheliometer. (Early form diagrammatic.)

degree. Langley employed gold, platinum, and palladium foil, thin iron strips, &c., about 10 mm. long, 1 mm. wide, and ·01 to ·002 mm. thick. Two of these were included in adjacent arms

* Pogg. Annalen LXXXIV., 1851, p. 411.
† Proc. Am. Acad. of Arts and Sciences, Jan. 12, 1881, Vol. VIII.

of a Wheatstone bridge, and when a considerable current was passed through this bridge it was found that an increase of temperature of either of the strips, amounting to one hundred-thousandth of a degree could be detected, and one ten-thousandth of a degree could be measured. He gave this arrangement the name of the actinic balance or bolometer (*βολη μετρον*). Since then the bolometer has been employed by numerous workers in America and Germany. One of the earliest in the field was Angstrom, who devised an instrument which he terms the pyrheliometer. The first instrument of this kind* employed thermo-junctions, and consisted of two small massive discs of blackened copper (Fig. 10) about 30 mm. diameter and 5 to 7 mm. thick, placed close together, but with a non-conducting partition between. In each of these discs a thermo-junction was embedded, and these junctions were connected in series with, but in opposition to one another, to a galvanometer, which thus indicated the difference between the temperature of the two discs. On allowing radiation to fall on one of these discs and shielding the other, the temperature of the former rose steadily and the rate of this rise could be easily obtained from the galvanometer deflection. But as the heat capacity of the disc was known from its dimensions, this enabled the amount of heat absorbed to be determined. This instrument is of interest as being the first which enabled radiation to be determined in absolute measure, but its sensitiveness was somewhat low. Angstrom, therefore, adopted the bolometer principle, and introduced his electrical compensation pyrheliometer,* which consisted of two exactly similar blackened bolometer strips, one of which received the radiation to be measured, while the other

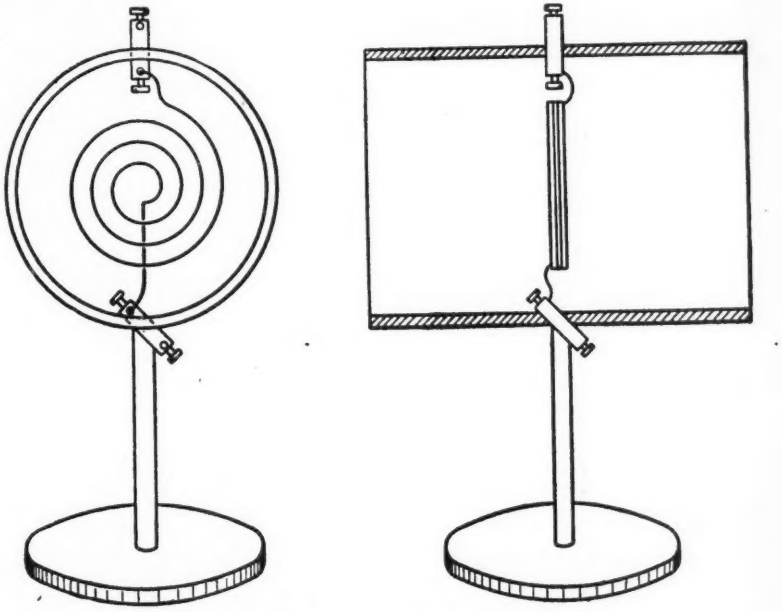


FIG. 9.—Svanberg's Galvanic Differential Photometer.

* Wied. Ann. XXXIX., p. 295, 1890.

* Wied. Ann. LXVII., 1899.

was traversed by a current which could be adjusted to raise its temperature to equality with the former. The power required to produce this equality of temperature, and hence of resistance, could be at once calculated from the current. Both strips being similar, no correction is necessary for convection or conduction.

The principle of the compensated bolometer has been employed by Kurlbaum, Callendar, and others, and found most valuable. For measurement of radiation over the visual range a photometer will, of course, serve, and many pyrometers have been devised on this principle, which will be described later.

(To be continued.)

On Reading in Bed.

READING in bed is considered by many medical men, no doubt with reason, to be bad for the eyes, and one ought, at least, to take reasonable precautions to render it as harmless as possible. It seems reasonable to suppose that a considerable amount of the strain caused in this way is attributable to the fact that precautions are rarely taken to secure even fairly good conditions of illumination. A person reading in bed is often content with a makeshift device that he would regard as quite unsatisfactory in the study.

It is, in fact, a little difficult even deliberately to secure satisfactory conditions, as much will depend on the posture which the person assumes while reading, and, in any case, a recumbent position is really inconvenient for reading purposes. In an ordinary bedroom the general illumination provided is rarely sufficient to enable any one in bed to read with comfort, and a special local illumination is therefore necessary. A lamp may be placed quite close to the head, and it is, therefore, most essential that the direct rays from the source should be screened from the eyes.

The plan of attaching a fixture to the wall above the reader's head is not entirely satisfactory. If the lamp is too low it is very apt to come within the field of view, while there is also a tendency for the light to throw a shadow of the reader's head on the book, unless he assumes a particular position. Probably the best plan is to use a properly shaded lamp on a table at the bedside, and to support the book on a suitable rest.

One illustration of the want of care on the part of people reading in bed is afforded by their trying to do so in remote country districts where the only light available in the bedroom is shed by candles.

Candles may serve the purpose of those who merely wish to go to bed and get to sleep as quickly as possible; but a single candle at the bedside yields far too weak a light to read by with comfort. Even supposing that the book is kept only one foot from the source and that the rays strike it vertically, we only secure an illumination of about 1 candle-foot, and this is now generally considered to be too low an illumination for continuous reading. As a matter of fact, however, the source of light will almost invariably be much more distant than this, and the attitude of the reader usually causes the rays of light to strike the book more or less obliquely, so that the effective illumination becomes but a fraction of the above value.

The constant flickering of the unshaded candle usually employed in such cases, and its dazzling effect, owing to its being necessarily so close to the head, are also undoubtedly very trying.

An Improved Form of Flicker Photometer.

By Lancelot W. Wild.

Some of the desiderata in an ideal photometer are the following :—

1. It must be sensitive and certain on lights of varying colour.

2. The rays must fall upon the illuminated surfaces perpendicularly, so as to reduce angle error to a minimum.

3. The illuminated surfaces must be both directly over the pointer, and should not extend on either side of it, if an ordinary scale and bar is to be employed.

4. When balance is nearly obtained it should be easy to perceive which way the head must be moved to improve the balance, without the necessity of rocking it to and fro.

5. If complete reversibility is required, both illuminated surfaces should be absolutely identical, and must be the same distance from the eye.

6. In a flicker photometer, in order to secure sensitiveness, the transition from one surface to the other must be sudden, and there must be no dark line crossing the field of view, such as the unilluminated edge of a card.

It is claimed that the new Wild Flicker Head complies with all the above. It is extremely sensitive, and partly because of this and partly because it complies with requirement No. 4, the correct balance is so quickly judged that fatigue of the eye scarcely comes into play.

Description.

A species of Bunsen disc of the form shown in Fig. 1 is rotated on its centre by a small electric motor. The disc is made by a special process which ensures it being symmetrical, *i.e.*, if used as an ordinary Bunsen the same reading will be obtained again when the disc is reversed in its box, which is not the case with most Bunsens.

The disc is also much more sensitive and freer from angle error than the average Bunsen disc.

The disc as it rotates is maintained true by means of guides in close proximity to that part within the field of view.

A small portion of the disc is viewed through a diaphragm, and, as the dividing line separating the transparent from the opaque portion of it passes the field of view, a flicker is seen, which disappears when the head is brought to the position of balance, so that both portions of the disc are equally illuminated.

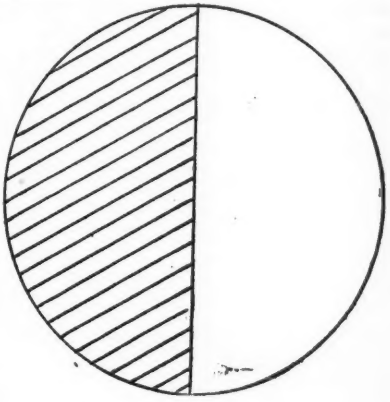


Fig. 1

The new improvement now made consists in the manner in which the disc is viewed. Both sides of the disc are viewed at once, and through the same eyepiece. The arrangement is shown in Fig. 2. P is a 60 degrees totally reflecting prism with a very sharp edge; L is a lens. At D is a diaphragm bent round the prism. MM are mirrors. On applying the eye to the lens one sees a circular field bounded by the diaphragm and with a thin black line, due to the edge of the prism down the centre. On the left of this line one sees the right-hand side of the disc and vice versâ.

The disc is purposely made so that the efficiency of the transparent part is slightly less than that of the reflecting part, consequently the two sides do not balance at the same point on the scale. Instead of attempting to reduce the flicker to zero, the operator moves the head till the two flickers on either side of the vertical line in the field of view are equal. If now the head is moved the least bit, an increase of flicker on one side and a decrease on the other is at once manifest, and the operator knows at once which way the head should be moved to improve the balance.

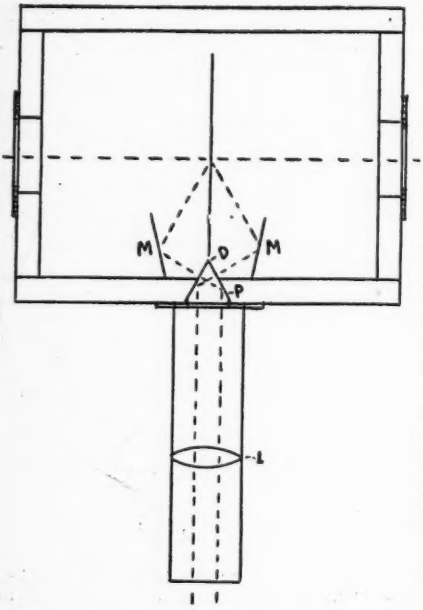


FIG. 2.

This double effect just doubles the sensitiveness, and partly because of this and partly because one does not have to hesitate before deciding which way one is out of balance, the whole operation is completed so quickly that fatigue of the eye has not time to set in.

It is found that it is not necessary to entirely eliminate colour flicker, and consequently the sensitiveness does not fall off as the colour difference increases to nearly the same extent as in other flicker photometers, the speed of which have to be increased when the colour contrast is great in order to eliminate colour-flicker.

Partly due to the rays falling upon the disc perpendicularly and partly due to the selection of suitable materials for the making of the disc, angle errors are practically nil. Turning the head on its pillar through an angle of 1 degree alters the reading $^1/_{10}$ per cent, as against fifty times this amount for a corresponding angular displacement with another well-known make of flicker head.

The disc is enclosed in a box eight inches long, and the light enters through bevelled holes $1\frac{1}{4}$ in. in diameter in brass flanges at either end. The disc is, therefore, well screened from stray light, a matter of considerable importance.

With a properly drawn scale and the lights correctly aligned, the same reading should be obtained on reversing the lights. Should, however, any doubt be entertained as to this, the head as a whole can be reversed by turning it over, an extra fitting being provided at the top.

A test for sensitiveness was made on one of these photometers against several other flickers. The results obtained, though depending somewhat upon the natural prejudices of the inventor, are set out below for what they are worth.

The special Whitman flicker had the disc cut so that the edge never crossed the field of view, and had to be worked upon a special bar and scale.

Type of Flicker.	Lights same Colour.	Pentane and Gas.	Red and Green.
	per cent.	per cent.	per cent.
Simmance ...	1·8	2·1	4·4
Ordinary Whitman	1·6	2·0	4·2
Special Whitman	·6	1·0	3·5
Wild, old type	·9	1·1	2·5
Wild, new type	·5	·6	·9

A New Variety of Incandescent Gaslight.

SOME of our readers have doubtless had the opportunity of visiting the showrooms in Cheapside, or the pavilion of the Universal Gas Methane and Buisson-Hella Co. at the Franco-British Exhibition, where some examples of an interesting and novel form of incandescent gaslight are on view.

This system represents a new departure in gaslighting, on which great expectations have been founded, and the following description, based mainly on information kindly afforded to *The Illuminating Engineer* by Mr. C. F. Killar, one of the directors of the company, may therefore be of interest.

The general nature of the incandescent device—the "bushlight"—will be best understood from the accompanying illustration, for the use of which we are indebted to the courtesy of the *Journal of Gaslighting.*

The actual incandescing material takes the form of a series of rods about 0·8 mm. in thickness, and usually 25 to 30 mm. in diameter. The composition of these rods forms the subject of two English patents by M. Laigle (Nos. 3785 and 9622 of 1908), who states the percentage composition to be as follows :—

Alumina	3·0	per cent
Berylla	2·0	,, ,,
Silica (or silicate of alumina) ..	1·0	,, ,,
Thorium oxide ..	92·8	,, ,,
Cerium oxide ..	1·2	,, ,,
	100·0	

These patents also discuss the use of oxides of lower melting point than berylla to serve as a permanent binding material, or berylla itself may be so used. When squirting the filament the whole material has to be reduced to a pasty, adhesive condition, necessitating the use of materials to serve as an agglutinant. Special mention is made of the need of securing removal of obnoxious residues formed from the binding constituents during the subsequent calcination, just as occurs in the case of some of the processes used in the manufacture of metallic filament lamps: pure gum arabic and ammonium oleate are mentioned as serviceable in this connexion, as they are decomposed by heat into volatile products. However, oxidizing materials are also included in the filament in order to completely remove undesirable carbonaceous residues. One characteristic of the process on which stress is laid is the production of the rod-filaments in a porous condition, the illuminating efficiency being thereby greatly improved.

As a result rods are obtained which are claimed to be quite exceptionally durable as compared with the ordinary incandescent mantle. Although these rods are sufficiently fragile to be deliberately broken (with some difficulty however) by pressure between the thumb and finger, it requires a very severe shock from without to affect them. Their rigidity is also stated to render them practically immune from the injurious effects of a severe draught on an ordinary mantle, and the eventually disintegrating action of continual lighting up and extinguishing the burners. Moreover, there is also the probability that careless handling of the mantle may merely snap off one or two of the rods and leave the rest intact, thus only slightly affecting the value of the glower as a whole.

Several illustrations of the ability of these mantles to withstand shock are afforded in the window of the premises in Cheapside. One such mantle is shown burning and being at the same time subjected automatically to a series of sharp shocks at the rate of about 50 a minute. A second mantle is exhibited, being dipped into water at regular intervals, but yet, apparently, continuing to yield its light unharmed after immersion.

The power of resisting shock attributed to these rod-filaments is being turned to special account in the design of portable lamps, capable of being lifted from one position to the other without danger of breakage, and for the purpose of motor-car headlights. Another probable useful application is to train-lighting.

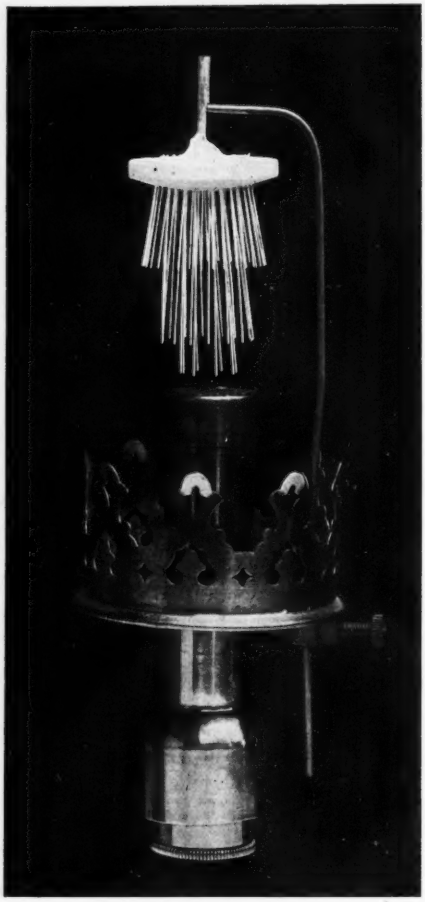


FIG. 1.

Apart from their toughness, however, it is also claimed that such filaments retain their initial candle-power almost indefinitely, and, indeed, gradually improve with use, for the subsequent heating seems in some way to complete the original chemical action and to cause them to incandesce with a given amount of gas more readily than before. Thus, we were informed of cases in which they continued to give as good results as was initially the case three or four years after installation.

The burner used with the "hella-bushlight" differs from those used with mantles of the ordinary variety, for instead of drawing up the flame outwards so as to envelope the mantle, it drives it up with some force centrally. It is understood, however, that burners can also be designed to burn petrol or acetylene if required. The efficiency of the arrangement at present on exhibition is said to approximate to that of ordinary mantles.

Although the only examples on show at present are of French manufacture and of the size most commonly used in France, there appears to be no difficulty in constructing the bushlight in different sizes; indeed, one would suppose that the method of mounting a number of separate rods was specially favourable to subdivision into sources of low candle-power.

It is also proposed to develope high candle-power sources for street-lighting, and for use on high-pressure systems. In this connexion the advantage claimed for these rod-filaments, of being practically immune from injury from wind or rain, would be a distinct advantage. The use of a higher flame-temperature may also be beneficial in enabling thicker rods to be used. For instance, it is hoped that such sources will be specially serviceable for the provision of intense lights for lanterns, lighthouses, and searchlights, and our representative was informed that a light of 5,000 candle-power was recently obtained by the incandescence of rods about one-eighth to one-quarter of an inch thick in the oxy-acetylene flame.

The bushlight is expected to prove useful for decorative purposes. Although usually worked up into rods,

it appears that the filaments can also be constructed in any desired fantastic shape—stars, baskets of flowers, &c.—when in the plastic condition. It is also stated that the colour of the lights can be varied over a wide range by altering the chemical composition of the rods, and that this quality, too, will prove of great value for decorative and special trade purposes. For instance, the rod filaments installed for the illumination of some works in Nottingham, where the manufacture of lace is carried out, were specially designed to yield light of a somewhat greenish hue, in deference to a prevalent impression among workers in this industry that light of this colour is most suited for close work, liable to tax the eyes.

Such are a few of the interesting qualities attributed to this new form of incandescent gaslighting. Meantime we await with interest the publication of the results of actual tests of the rod-filaments, and hope to be able to supplement this description with some figures on the subject shortly.

The Generation of Acetylene Gas from Compressed Carbide Briquettes ("Brikettid Light").

By H. Koffler, of Vienna.

The manufacture of compressed and treated carbide, to which some inactive constituent is added, is carried out with the object of improving the conditions of gasification of the material, and rendering it less hydroscopic.

When carbide is treated with water, its hydroscopic qualities not only give rise to considerable loss and gradual deterioration of the material, but also constitute a source of danger, owing to the fact that the generation of gas continues after its period of actual use is passed. From the earliest beginnings of the acetylene industry attempts were made to avoid the inconveniences and dangers attending "after-gassing," by the design of automatically operated apparatus; the difficulties which were experienced, however, subsequently led to the abandoning of this method. The only apparent method of rendering the generation of acetylene gas less dangerous seemed to lie in the use of systems of hand-feeding; but even this method is naturally open to considerable objection from the commercial standpoint. For, in order to develope and store the whole of the gas available from a charge of carbide, a correspondingly large vessel must be employed, the high cost of which renders the application of the method impossible in the case of small installations of one to thirty lights.

More recently attempts have been made to render the material less hydroscopic, by adding some inactive substance, such as sugars and fatty materials, to the carbide. The variety of carbide produced in this way was better able to withstand dampness of the air, but it was still open to the objection that the danger of "after-gassing" was not avoided.

The briquettes invented by the author are specially designed to meet these conditions. They consist of finely granulated carbide intimately mixed with an inactive binding material, and forced into the desired shape under pressure. As the result we obtain a material possessing the following qualifications:—

1. *Great capacity for resisting damp*, in virtue of which the briquettes do not deteriorate with time, and can be stored as required, without the fear of gradual loss of gas owing to their slow decomposition.

2. *Absolutely uniform evolution of gas.*—The briquettes only evolve gas when brought into actual contact with water. They dissolve away in the apparatus at a perfectly uniform rate, because each individual particle of carbide only becomes active as its

protecting covering goes into solution in the water.

3. *Complete absence of "after-gassing."*—The quality of the briquettes described in the last paragraph also explains their freedom from "after-gassing." For, after the water has been forced out of the apparatus, the briquettes are left freely suspended in the gas generated, and do not come into actual contact with water; therefore, as explained above, they are practically unaffected by the surrounding water-vapour, and retain their good qualities until the time that the apparatus is again put into use.

4. *Complete gassification.*—One great advantage of briquettes constructed according to the process described over the use of ordinary carbide is that the undigested lumps, which remain in such a case after the acetylene has been evolved, are here completely avoided. The briquettes gradually dissolve away into the water, and are separated from the moist precipitated residue in the process; water can only again find access into the vessel when the very last volume of gas has been generated from the active material.

The behaviour of the briquettes, as contrasted with carbide of the ordinary variety, is illustrated by the results in Table I., which were obtained by an independent outside test. In the case of the ordinary acetylene generator, gas continued to be evolved for a long time after the cock was turned off, until eventually it overcame the pressure of the water and began to escape; while in the case of the briquettes no serious rise of pressure occurred.

The author believes that the method indicated has finally solved the problems referred to, and by the aid of a simple and cheap form of apparatus. The apparatus enables a dry and chemically pure acetylene gas to be produced, the temperature of decomposition being kept low, and the development of polymerides of acetylene, as an impurity, being thus avoided. The gas so generated has, therefore, the advantage of being well adapted for use with incandescent mantles. In Austria-Hungary and in some parts of Germany apparatus using compressed briquettes is exempted from the regulations affecting other apparatus for the generation of acetylene which forbid the installation of apparatus in dwelling-houses; it is expected that other Governments will shortly follow suit. This is the more to be desired, as the briquette method is especially favourable to the installation of acetylene light by small consumers, and will probably prove of great assistance in enabling acetylene lighting to compete with other illuminants in this field.

TABLE I.

Result of comparative Test of 1,000 *grammes Brikettid, and* 1,000 *grammes ordinary Carbide. Test made with Brikettid apparatus.*

I. *Brikettid.*—The apparatus was used continuously for one hour. Consumption of gas by burner = 100 litres per hour. Pressure 10·5 cms.

The cock was then turned off, and the subsequent manometer readings were:—

After	5 minutes	...	...	16·5 cms.
,,	30 ,,	...	...	19 ,,
,,	1 hour	...	...	20 ,,
,,	2 hours	...	...	20·5 ,,
,,	7 ,,	...	...	21·5 ,,
,,	20 ,,	...	...	19 ,,
,,	25 ,,	...	...	19 ,,

Efficiency 260 litres of gas per 1,000 grammes of Brikettid.

Temperature developed, 32·5° Centigrade.

II. *Ordinary Carbide.*—The apparatus was used continuously for one hour. Consumption of gas by burner = 100 litres per hour. Pressure 16·17 cms.

The cock was then turned off, and the subsequent manometer readings were:—

After	5 minutes	...	...	26 cms.
,,	30 ,,	...	...	30 ,,
,,	1 hour	...	...	33 ,,
,,	3 hours	...	...	37 ,,
,,	8 ,,	...	...	42 ,,

After 8 hours, escape of the gas occurred, owing to the pressure generated having exceeded that of the water.

Efficiency, 290 litres of gas per 1,000 grammes of Carbide.

Temperature developed, 54·5° Centigrade.

Some Notes on the Proceedings of the Annual Meeting of the British Association.

AN account of the proceedings of the British Association at Dublin this year would be incomplete without some reference to the death of Lord Kelvin, whose presence helped to lend such distinction to the Leicester gathering last year, and to whose work Dr. Francis Darwin paid tribute in his inaugural address. Happily the attendance this year again reached a high figure, and while but one communication dealing specifically with photometry and illumination was given to the meeting, many of the addresses were of exceptional general interest.

Reference must first be made to the communication from the director of the **National Physical Laboratory** on the subject of the STANDARD OF LIGHT now to be adopted.

Mr. Paterson, it will be remembered, in 1904 presented the formula—candle-power$=10+0{\cdot}066(10-e)$—for the correction of intensity of the Harcourt standard for atmospheric moisture, the lamp having its correct value when $e=10$, *i.e.*, when there are present in the photometer-room 10 litres of moisture per cubic foot of air. Under these circumstances the humidity was measured with an ordinary wet and dry bulb thermometer. At the Reichsanstalt, however, an Assmann ventilator wet and dry bulb instrument has been used, and this hygrometer was recommended by the International Photometric Congress at Zürich in 1907.

More recently the value of the various hygrometers for the measurement of moisture has been studied more completely, and it has been ascertained that a difference of as much as 20 per cent between the readings of the ventilated and unventilated hygrometers exists. According to the Assmann instrument, which is regarded as giving a more consistent result than the ordinary hygrometer, the moisture actually present would be only 8 litres per cubic metre when a hygrometer of the ordinary variety would indicate 10.

If the Assmann hygrometer be adopted, Mr. Paterson's formula, therefore, becomes — candle-power $=10+0{\cdot}066(8-e)$—and the standard value of the lamp corresponds to 8 litres of moisture per cubic foot, instead of 10 as hitherto. The National Physical Laboratory adopted the latter as a mean value for the conditions in this country on the basis of investigations at their own observatory and at the Meteorological Office, carried out with the ordinary unventilated hygrometer, and some might regard it as objectionable to change the existing directions.

If, however, the Assmann hygrometer is adopted, and the 10 litres of moisture adhered to as the standard condition, it would involve a change of 1·3 per cent in the standard light. Now the existing unit has been adopted by the Engineering Standards Laboratory for glow-lamp testing, and utilized for the past three or four years for the purpose of creating many sub-standards in actual use to-day. For this and other reasons it is proposed to keep the *light-value* of the standard constant, but to use the Assmann hygrometer, and in future to adopt 8 litres per cubic foot of air as the standard condition of humidity. This proposition meets with the approval of the Gas Referees.

One important consequence of the change, pointed out in correspondence with the Bureau of Standards of America, is as follows.

The joint experiments carried out on the ratio of the Hefner to the Pentane lamp during 1906, in France, Germany, and England, led to practically identical results in Germany and England. Thus the German value was 0·909, while Mr. Paterson, at the National Physical Laboratory, obtained 0·907. Now the standard condition of moisture at the Reichsanstalt is 8·8 litres, while that at Teddington was 10 litres, measured by the unven-

tilated hygrometer, and subsequently found to be 8 litres measured by the ventilated instrument.

But in either case a correction for the different standard conditions is needed in order to compare the Hefner and Pentane standards on an equal basis. From Mr. Paterson's formula and the results referred to above we find that, in using 8·8 litres in both cases :—

$$\frac{\text{Hefner candle at 8·8 litres}}{\text{Pentane candle at 8·8 litres}} = 0{\cdot}908,$$

Taking 10 litres as the standard conditions of moisture in England, we have :—

$$\frac{\text{Hefner candle at 8·8 litres}}{\text{Pentane candle at 10 litres}} = 0{\cdot}915\ ;$$

a result which was accepted at Zürich within ± 1 per cent.

But if we adopt the Assmann hygrometer and take 8 litres as the standard humidity for the pentane lamp, we obtain :—

$$\frac{\text{Hefner candle at 8·8 litres}}{\text{Pentane candle at 8 litres}} = 0{\cdot}903.$$

And this figure approaches the convenient value 0·900 so closely as to enable us to say, within a margin of ± 1 per cent, that the Hefner is $\frac{9}{10}$ of the Pentane candle. An equally convenient result is attained as regards the comparison of the Bougie-decimale and the Pentane, for whereas—

$$\frac{\text{Bougie-decimale at 10 litres}}{\text{Pentane candle at 10 litres,}} = 1{\cdot}02,$$

we find—

$$\frac{\text{Bougie-decimale at 10 litres}}{\text{Pentane candle at 8 litres}} = 1{\cdot}006\ ;$$

and this ratio, within the limits of photometrical measurement, can be taken as unity. Thus we arrive at an interesting result that might, perhaps, hardly have been considered possible, namely, that the ratio between the pentane and the Hefner and Bougie-decimale, become altered to convenient round numbers, without the actual value of the light standards in either of the three countries being altered.

The convenience of using 8 litres as a standard, therefore, may be considered so great as to justify the International Photometrical Commission to modify the value of 0·915 for the value of the Hefner to the Pentane candle, which was based upon the information previously supplied by the laboratory.

This change does not remove another discrepancy of over 1 per cent, which has not yet been satisfactorily accounted for. This discrepancy is found to exist between the results obtained when the Hefner and the Pentane are compared direct, and those obtained when they are compared through the intermediary of electric glow-lamps.

Thus the ratio obtained by exchanging standardized glow-lamps between the various laboratories has been determined as follows :—

Paterson,	1905	..	0·891
Fleming,	1905	..	0·886
Sharp,	1905	..	0·890
Hyde,	1906	..	0·894
		mean	0·890

This want of agreement is considerably reduced by the change of the ratio of the Hefner to the Pentane from 0·915 to 0·903 ; but there is still something to be discovered, and this, with the co-operation of the Reichsanstalt, is now being examined.

Dr. Glazebrook's communication also mentions the possibility that the present method of defining the humidity by the number of litres of moisture present in a cubic metre of pure dry air may be modified. This method was followed by Liebenthal.

It appears, however, to be more usual to specify the number of litres of moisture in an actual volume of 1 cubic metre, including the CO_2, moisture and any other gases present. It is stated, however, that, even should this method be adopted in future by international agreement, it will lead, within the limits of possible accuracy of working, to virtually the same result.

In the Physiological Section much interesting ground was covered relating to general questions from which the study of illumination cannot be dissociated. Special reference may be made to the report of the Committee on the 'Condition of Health Essential to the Carrying on of the Work of Instruction in Schools, and the discussion on 'The Instruction of

SCHOOL TEACHERS IN PHYSIOLOGY AND HYGIENE.'

Prof. Sherrington, for example, likened the human body to a machine, and insisted that the school teacher, who might be considered in this sense a human engineer, ought to have some knowledge of physiology and some insight into the working of the healthy human body. In the present age the daily life of the school child was coming more and more under the supervision of the school-teacher. The medical inspection of school-children, again, was now an accomplished fact, and in order to make his work efficient, the medical officer would be obliged to rely upon co-operation of the teacher.

As a matter of fact, physical breakdown was not infrequently more or less due to defective educational methods, and the squinting child was very often a product of the schoolroom.

Prof. F. Gotch, again, remarked that he desired to see the teacher acquire a knowledge not only of hygiene, but also of physiology, and thought that a knowledge of those they proposed to instruct was quite as essential to the teacher as any other recognized system of educational training.

He could not understand how it was that another nation was prepared to maintain an expensive navy and also to give large sums of money to technical instruction of any variety, where we were unable even to spend money on the adequate training of our teachers.

When we observe the difficulties experienced by the medical profession in securing the carrying out of many of their general recommendations, it is hardly to be wondered at, perhaps, that the claims of illumination in schoolrooms, &c., which, of course, are only a part, though a very important part, of the general physiological conditions that require attention, have not as yet received the recognition they deserve. At the same time there seems some danger that the importance of this point both to the educational and medical authorities, may be lost sight of. It may be remarked, for instance, that the report of the committee on the conditions of health essential to school work, to which reference has already been made, contains no reference to illumination. The questions of ventilation, temperature, humidity, &c., and the number of cubic feet of air per individual, are discussed, but the equally essential question of the amount of illumination required by a child for certain classes of work is not specified.

As has been frequently pointed out in *The Illuminating Engineer* (vol. i. No. I. p. 58, Special Section, ' Illumination and Eyesight '), medical authorities are agreed as to the serious handicap to children of working under a bad illumination, and the strain to which it may expose them at a critical period in their development. The squinting child, referred to by Prof. Sherrington, might quite conceivably owe his defect to his having been obliged to work by badly placed and inadequate lights; while educationalists should be alive to the folly of expecting good work from children who are really unable properly to see the letters they are striving to decipher.

An important recommendation put forward by the Committee is that a Royal Commission should be appointed to deal with the subject, and it is to be hoped that in this case *all* the essential conditions of health will be studied, and that the subject of illumination will receive its due share of attention.

Among the other papers in this section may be mentioned several which, though purely physiological in character, might prove to contain suggestions of considerable value to those concerned with illumination, and for this reason: there seems to be a want of some convenient and ready method of determining the physiological effect of different systems of lighting; in schoolrooms, for example, it is highly probable that bad systems of lighting are responsible for mental fatigue, merely by increasing the natural difficulties of the tasks on which children are engaged.

In this connexion the paper by **Mr. H. Sackville Lawson** on ' SOME ASPECTS OF MENTAL FATIGUE,' is suggestive. According to this suggestion mental conditions may be recognized by the state of sensitiveness of the skin.

Intellectual effort causes an accumulation of waste and poisonous material in the brain cells, and this reacts on the whole system, producing a change in skin-sensitiveness all over the body.

The sensitiveness of the skin is studied by means of a very simple form of instrument, the "Æsthesiometer," which is merely a modified pair of compasses. In conducting an experiment it is only necessary to determine the distance apart on the skin at which the impressions of the two points of the pair of compasses fail to be recognized as consisting of two distinct sensations. The author gave a series of graphs of skin-sensitiveness of students, professors, and a vicar in a surburban parish, &c., enabling the effect of mental effort on different days to be clearly demonstrated. Such a simple method of studying the subject may commend itself to educationalists engaged in investigating different methods of teaching, and might also, as indicated above, prove of value for the purpose of studying the effect of different systems of illumination.

In the same way the contribution of **Prof. Francis Gotch** on 'CERTAIN FEATURES OF RETINAL PHOTO-ELECTRIC PHENOMENA' is not without interest to the illuminating engineer. The considerable amount of attention now being devoted to photo-electric effects on the retina may lead to extremely valuable knowledge as to the means by which vision is accomplished, and it seems reasonable to hope that it may suggest a means of studying the effect of fatigue caused by different illuminants on the eye, and the exact influence both of the visible rays in the spectrum and also the invisible ones, about the action of which there has recently been so much discussion.

Dr. Edridge-Green delivered a paper on 'COLOUR-BLINDNESS AND COLOUR-PERCEPTION,' in which he discussed the classification of those having defective colour-vision. An important item in this division was the recognition that two classes of colour-blindness exist. In one case the loss of colour perception is accompanied by loss of perception of *light;* in the other it is not.

The speaker also explained his method of testing colour-blindness, by the "Lantern," "Classification," and "Spectrum" tests, in which the examinee is required, not merely to match, but to state the actual colours correctly, and to show the size of the portions of the spectrum which appear to him monochromatic.

Sir Wm. Abney and others took part in the discussion on this paper, and **Mr. L. Gaster,** who was present as Editor of *The Illuminating Engineer*, pointed out the practical importance of these physiological questions. Now that so many different varieties of illuminants were coming into use, and illuminants yielding such widely different spectra as the flame arcs and the mercury lamps, it seemed advisable to consider whether prolonged working under such sources of light might not lead to undesirable physiological effects, such as a distortion of normal colour-vision. He therefore inquired whether Dr. Edridge-Green had ever undertaken any tests with this object, and suggested that on such questions the co-operation of the engineer and physiologist was very much needed.

It was generally recognized by those present that this would be a profitable line of research, and that, generally, modern conditions of illumination offer a field of considerable interest to the medical profession and the physiologist.

Among various other papers dealing with physical subjects of interest, mention may be made of that by **Prof. H. H. Turner** on 'THE RELATION BETWEEN INTENSITY OF LIGHT I, TIME OF EXPOSURE, t, AND PHOTOGRAPHIC ACTION.' It would be natural to suppose that the photographic action of light would be proportional to It. Sir Wm. Abney, however, has expressed the view that this relation does not invariably apply, and the author, in agreement with these and other published results, finds that a more complicated law represents the exact conditions more closely, and prefers the relation,

$$\text{Photographic action} = I \times t^{0.8}.$$

Mr. H. Stansfield described some experiences with the echelon spectroscope, and **Mr. G. A. Hemsalech** explained

a new method of obtaining the spectra of flames devised by the author in conjunction with **M. de Watteville**. A glass bulb encloses a spark-gap between two electrodes of the metal whose spectrum it is desired to obtain. Air, on its way to a bunsen burner, is caused to pass through this glass bulb. When powerful electric sparks pass across the electrodes, metallic vapour issues from the latter and diffuses into the surrounding air, combining and forming very finely divided particles, which are carried forward into the bunsen-flame, and impart to the latter the characteristic spectrum of the element under examination.

There were other papers read before the Association which, while not dealing specifically with any aspect of illumination, contained food for thought for those in all sections of the engineering profession. Among these special mention may be made of **Prof. L. C. Miall's** 'ADDRESS TO THE EDUCATIONAL SECTION.' Many of his generalizations regarding education evoke immediate sympathy; unfortunately, as Prof. Miall admits, we do not always act upon our hardly-earned convictions in these matters, but are carried on by the inertia of former educational systems.

Prof. Miall expressly points out how book-learning as a means to an end may be a useful tool, but as an end in itself is often merely stupefying. "Happily for us a great deal that we once knew and might foolishly wish to retain in our knowledge quickly fades from the memory....It is not nearly so necessary to know more things as to know them better, to know what to do with them." And we must all recognize the necessity for deliberate choice as to what it is we mainly desire to know.

Yet, though most people agree, in the abstract, that scientific information is of relatively small value in comparison with the scientific method and scientific spirit, the teacher of science still loads the memory with facts, and the examiner bases his results on the quantity that the candidate has been able to accumulate.

In considering the subject of technical education Prof. Miall criticizes those methods that consist merely in supplying information directly applicable to the industry in question. "The information is not accurately lodged, either in the memory or the note-books of the students; it soon becomes obsolete in consequence of the advance of knowledge; and it does little to cultivate intelligence or the power of doing."

On Literature and Rhetoric, too, Prof. Miall has some interesting comments to make, especially when he points out that the growth of the scientific spirit must tend to weaken that variety of literary and rhetorical art which may fitly be described as insincere eloquence: "Rhetoric seeks above all to persuade, and in a completely scientific age men will only allow themselves to be persuaded by force of reason. Even in our imperfectly scientific age those men gain most by speech who have something important to say, who say no more than they know, and who use all possible plainness."

Space does not enable us to do more than briefly mention two others among the many communications of exceptional scientific and practical interest. 'THE REPORT OF THE COMMITTEE DESCRIBING SOME EXPERIMENTS FOR IMPROVING THE CONSTRUCTION OF PRACTICAL STANDARDS FOR ELECTRICAL MEASUREMENTS' contains some exceedingly important data, especially that referring to the work on some of the fundamental units, recently undertaken at the National Physical Laboratory, and recently published in *The Philosophical Transactions*.

Lastly, mention may be made of the paper by **Capt. H. Riall Sankey** on 'THE UTILIZATION OF PEAT FOR MAKING GAS OR CHARCOAL.' A scheme for the distribution of electricity generated by gas engines driven by gas obtained from peat has, it will be remembered, come before a Select Committee of Parliament this year; it may be of interest to some of our readers to mention that a complete account of these proceedings occurs in a special number of the *Irish Engineering and Industrial Review* for September in this year.

Some Effects of Light, Visible and Invisible.

(*Continued from p.* 756.)

HITHERTO we have mainly referred to the effects of *invisible* light of short wave-length upon the eye and the skin. There are, of course, vast stores of energy at the other end of the spectrum that take the form of dark heat rays, and may also be of influence. As a matter of fact, however, such investigations as have been published on this subject seem to convey the impression that no very definite and obvious effects arise when the sources of light are kept at a reasonable distance from the eye. Extreme heat, however, has been found to exert a drying and irritating effect upon both eyes and skin. Naturally a deliberate attempt to produce the heat rays in excess can cause more pronounced physiological effects, and has been utilized in certain courses of medical treatment.

A question of greater significance to the illuminating engineer is the effect of the visible rays in the spectrum. On this point comparatively little information that can be applied to practical conditions seems to be available. As explained above, common experience forbids the assumption that there is any very violent difference between the effects of ordinary illuminants, though there may exist small changes that act progressively, and eventually become worth taking into consideration. Here again it is sometimes suggested that certain rays have beneficial influence or otherwise on the skin, the pulse, &c. These, of course, are questions for the physiologist to study.

A great many conflicting and inadequately supported views are often put forward as to the beneficial physiological effects of certain illuminants. It is, for instance, known that the greatest sensitiveness of the eye to light occurs in the yellow in the spectrum, and Nichols has attributed this to the gradual development of the eye so as to utilize natural daylight to the best advantage (see abstract, *Illuminating Engineer*, August, 1908, p. 686). From this point of view it has been argued that yellow light must be that for which the eye is most perfectly developed, and amber-coloured glasses have occasionally been prescribed on this account.

On the other hand, it seems that the mere fact that the eye is most sensitive to yellow light is not necessarily a proof that the tendency to fatigue is least in that region of the spectrum. It might, indeed, be argued in the same way that because the pigmental change, or whatever it is that is responsible for the sensation of light, is most pronounced at this point, therefore such pigment would most readily be used up, and therefore the fatigue would be *most* evident in the case of yellow light. It also seems to be believed by many physiologists that chemical action on the retina becomes more and more pronounced with shorter wave-length, until in the ultra-violet the effect becomes extremely violent. But it need not be assumed that this effect is identical with that responsible for the sensation of light.

An entirely different view has been taken by those who exalt the mercury vapour lamp on the ground that it contains no red rays. This is founded on the supposition that red rays are most trying to the eyes. Steinmetz, indeed, has gone so far as to trace a connexion between the quality of the light and the opening of the pupil-orifice. The aperture appeared to contract most readily in the case of red light. It was, therefore, supposed that the red end of the spectrum was most irritating, the eye tending to protect itself by the closing of the pupil-orifice.

As regards the eye this result is certainly not in accordance with those

of other workers. There really does, however, seem to be some ground for the belief that the colour red is, in some way, of a stimulating and exciting nature. There is a general impression that the red end of the spectrum is cheerful and stimulating, and that the blue end is correspondingly subduing and depressing. In the same way we speak of "warm" and "cold" tones. It is something more than a coincidence that we have selected red for the most exciting ideas; it is the symbol of danger, of war, and of revolution, and, as is well known, many animals—and proverbially the bull—are subject to its influence. So well does this appear to be realized by the medical profession, that a method of treating the insane has been founded upon the effects of red and blue light respectively.

A hypochondriac—a person, that is, who suffers from unreasonable depression of spirits—is placed in a room from which all but red light has been excluded. As a result his depression is stated to disappear and to be ultimately replaced by cheerfulness. After this point it is wisest to remove the patient, as his cheerfulness eventually turns to extreme excitability. Maniacs, on the other hand, who are abnormally excited, are said to be quieted by living in a room from which all but the *blue and violet* portions of the spectrum are excluded. This has a calming effect, but again must not be continued too long, as the ultimate result of exposure to energy of this kind is depression or even stupefaction.

Miss M. A. Cleaves (see 'Light Energy') has even recorded a supposed method of treatment of political offenders by shutting them up for a long period of time under blue light. As a result their faculties become numbed, and eventually, when released, they are no longer in a condition to cause the authorities any serious concern.

In all these circumstances, we must remember, we are only dealing with comparatively small quantities of monochromatic light, such as is commonly produced by putting blue glass in front of sunlight, and thus extracting the relatively minute store of energy that appears in the form of the blue and violet rays. When special efforts are made to concentrate light of this description we may expect to secure more immediate effects. Thus Dr. Radard of Geneva is reported to have successfully utilised the application of blue light in a concentrated form to produce local anæsthea for purposes of dentistry. The same effect has been known in the United States for several years, and concentrated blue light has actually been utilized as an anæsthetic, and allowed to play upon the part of the body on which it is desired to operate and so produce temporary insensibility. The advantages of such a form of anæsthetic, if its value be confirmed, would seem to be worth attention.

Seeing that such apparently violent effects can be produced by monochromatic light, and that these phenomena appear to be seriously considered by physiologists at the present day, it seems legitimate to inquire whether the so-called "warm" colour of certain varieties of illuminants has not a basis in actual physiological experience. It will be found that many people have a dislike for the whiter light of the carbon arc, which approaches daylight more closely in spectral composition than does the carbon filament incandescent lamp. They consider it depressing and cold.

On the other hand, there is a general feeling that the yellow tones of the oil-lamps, and to a less degree the ordinary carbon filament glow-lamp, are stimulating and "cheerful." It seems, therefore, conceivable that the predominance of red rays in the spectrum of these illuminants really does stimulate, and thus render them specially effective for festive occasions when people are gathered together and desire to be cheerful.

Another interesting and ingenious suggestion to account for this desire for the red and yellow is based on mental association. All the original illuminants were ruddier in hue than those now coming into use.

One of the very earliest and most primitive sources of light was the

camp fire, and the pine-torches of the ancients and the middle ages, the crude oil-lamps, and the candle show a marked tendency to lighten in tone. More recently we have learned to make use of higher temperatures of incandescence, and this has resulted in a growing accentuation of the blue end of the spectrum and a whiter light.

One can therefore believe it possible that mankind has gradually become accustomed to associate the red and orange tones of the spectrum—the hue of the cheerful firelight within—with warmth and festivity, while the bluish shades are associated with the hues of twilight and the coldness without.

Yet it does not follow that the physiological effect of such illuminants, though pleasant, is to be preferred to that of daylight. Their mild stimulation is not necessarily the best for continuous use.

On the whole, when we consider how little is really generally known about the physiological influence of light, we may feel assured that our wisest course is to imitate the natural daylight, to the best use of which our eyes have been gradually developed, as closely as possible. Fortunately the light yielded by most artificial illuminants now in use resembles daylight fairly closely. Other more peculiar forms of radiation we may utilize for special purposes, but we ought to be slow to recommend their continuous use until we feel quite certain that there is no danger of their giving rise to any undesirable physiological effect.

J. S. D.

Cleaning Tungsten Lamps and Reflectors.

In a recent number of *The Electrical World* attention is drawn to the need for careful periodical cleaning of installations of tungsten lamps and prismatic reflectors. In a large city where much soft coal is used the lighting of a shop may deteriorate by from 10 to 35 per cent during a period of six weeks, simply owing to the deposit of dust and dirt.

Owing to the fragility of the tungsten filament, the necessary periodical cleaning must be carried out with care. The lamps should be cleaned while the filament is burning, and therefore in a more plastic condition. The lamp should be washed with a fairly moist cloth and subsequently wiped clean; but the cleansing of the reflectors should be carried out with the aid of a damp brush with stiff bristles, so as to get into the crevices of the prisms of the reflector satisfactorily.

In this connexion it is interesting to recall that a well-known firm in Germany deprecate the rubbing of the bulbs of tungsten lamps with dry cloths, on the ground that this may cause electrification of the outside of the bulb, with the result that the long tungsten filament is attracted and snaps off. For the same reason it is regarded as inadvisable to coat the lamp-bulbs with coloured varnishes, &c., containing shellac, which are easily electrified by friction. Presumably, however, this only refers to the older type of lamp in which the method of supporting the filament allowed it an undue amount of freedom.

Owing to the brilliancy of the tungsten lamps it is well for the operator to make use of a pair of dark glasses.

Cleansing ought to be carried out about once a month.

It is also a good plan to keep a stock of a few clean reflectors in hand, and to replace the dusty one whenever it is necessary to renew a broken tungsten lamp. The opportunity can then be taken to clean the old reflector thoroughly. Under ordinary circumstances to attempt to remove the reflector is to run some risk of breaking the fragile filament of the lamp used with it.

Some further Examples of Shop-Window Lighting by Gas.

In a recent number of *The Illuminating Engineer* attention was drawn to a newly introduced system of shop-window lighting, according to which the sources of light are placed behind panels of diffusing glass installed above the contents of the window.

The illustration shown in Fig. 1 is another excellent example of this method of lighting, It represents a shop in Richmond, Ind., U.S.A., lighted by gas by the Welsbach Co., to whom we are indebted for the block here utilized. The photograph was taken by the aid of the light in the window alone, necessitating a twelve-minute exposure.

An inverted mantle equipped with a concentrating conical silvered reflector is placed above each panel, and this, in conjunction with the diffusing action of the glass, provides a strong and uniform downward illumination. The piping is brought up at the rear of the window, the gas-cock being placed in a convenient position. The distance of the lamps above the glass is also sufficient to enable a fitter to attend to the mantles, and occasionally to clean the glassware and dust the glass "deck."

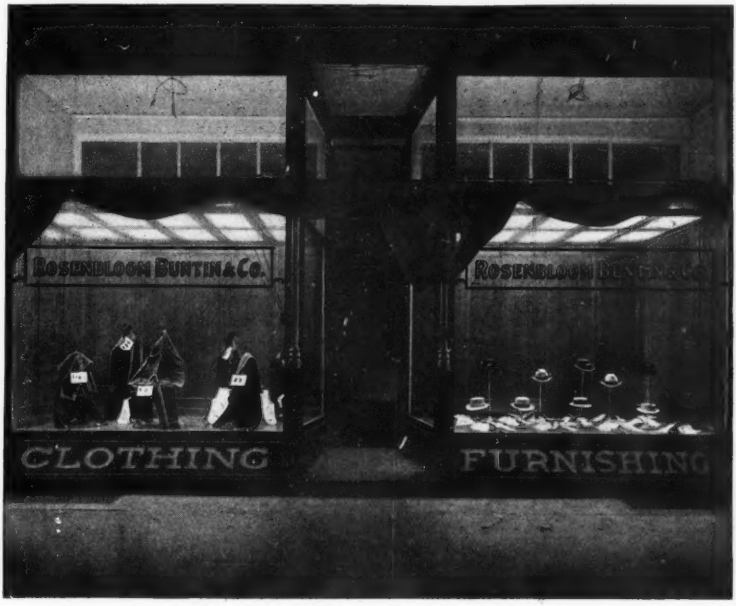


Fig. 1.—Show window, Richmond, Ind., U.S.A. Night View. Twelve minute exposure.

In this case electrical ignition is installed, batteries and induction coil being placed below the floor, and the switch beside the gas-cock, so that in order to light up it is only needful to turn on the gas and press the button.

Some other interesting examples of the "open" as opposed to the decked-in system of window-lighting are shown in Figs. 2 and 3. The shop exhibited in

Fig. 2, for instance, had a particularly high ceiling, and this permitted the use of individual gaslights equipped with suitable diffusing reflectors, placed on the ceiling well out of the normal range of vision; the object in this case was again to produce a uniform, even illumination, free from "spotty" patches of light and shade. In this case also the piping was effectually concealed behind the panelling at the top of the window. The interior purpose of uniformly illuminating both the contents of the window and some of the counters immediately to the rear of it.

Other sources serve the combined purpose of illuminating the sign "Cigars," and the goods in the window, being, at the same time, very effectually screened from the direct range of sight. This shop is likewise provided with a "jump-spark" system of electrical ignition, the battery and switch being



Fig. 2.—Show window in Philadelphia, U.S.A. Night view. Fifteen minute exposure.

decoration of this store was executed in dark Flemish oak, so that an intense illumination was specially desirable.

The tobacconist's, shown in Fig. 3, affords a second example of the open shop-window lighting, but in this case the window was exceptionally deep rather than high. In addition to the lights employed to illuminate the interior of the store, advantage is also taken of lamps placed in line round the top of the window, which serve the packed away in an easily accessible cabinet.

Yet another example of the use of the open system is the carpet-store shown in Fig. 4, where a uniform illumination is secured by a series of lights with reflectors spaced along the top of the window, and Fig. 5 once more illustrates the use of concealed lights to bring the goods in the window into prominence without offending the eye.

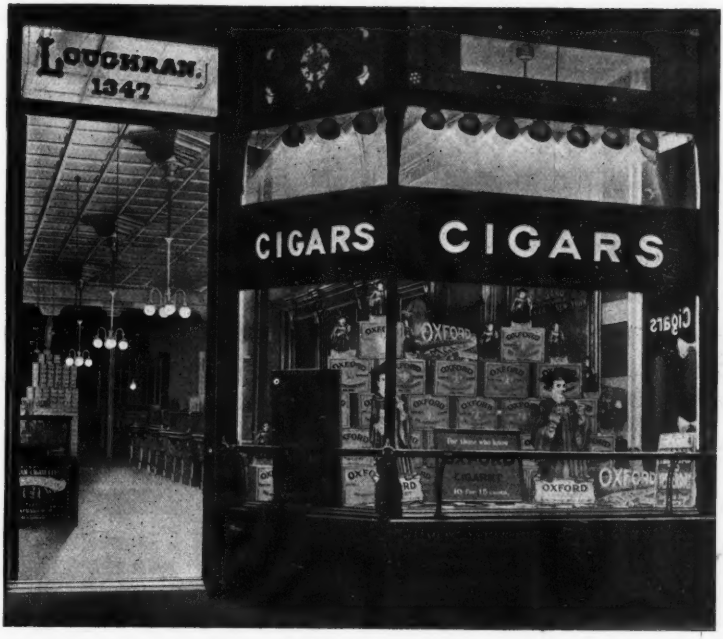


FIG. 3.—Tobacco store, Washington, U.S.A. Night view. Twelve minute exposure.



FIG. 5.—Display of Clothing Illuminated by Concealed Lights.

In all these windows the same general principles are aimed at. In each case it is desired to produce an even diffused illumination, and at the same time to conceal the sources producing it in such a way that the direct rays from them do not enter and dazzle the eyes of customers on the pavement.

Provided this is accomplished the salesman is justified in using what would be regarded as an abnormally high illumination for other purposes. For in order to attract the attention of passers-by, and to induce them involuntarily to form the habit of looking into this particular window, it is essential to adopt some method of lighting which both shows the goods to the best advantage and causes the window to "stand out" amidst its surroundings.

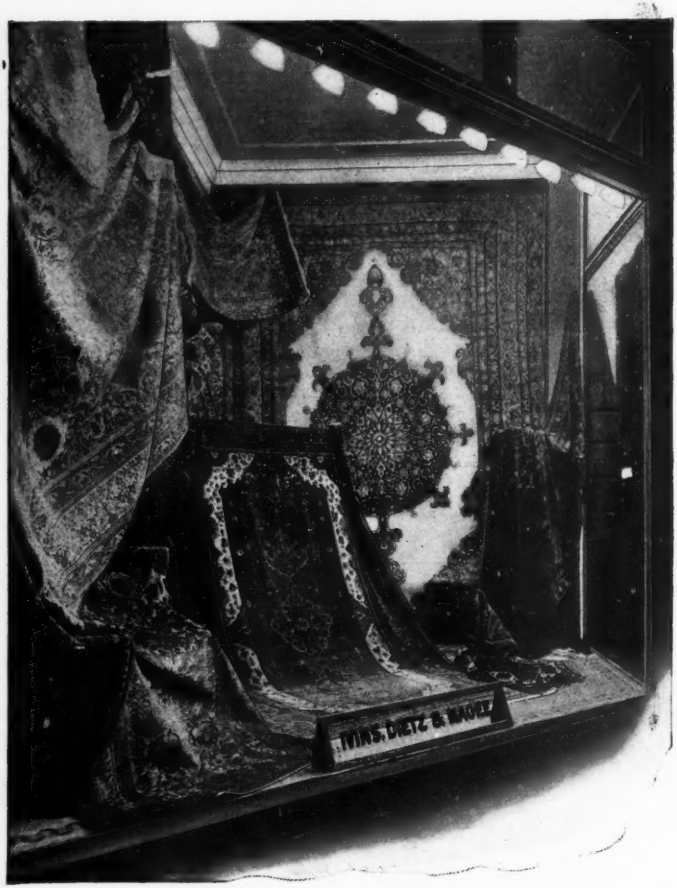


FIG. 4.—Show window of Carpet Store illuminated by means of Reflex Gaslights.

The Need for Good Illumination from the Moral Standpoint.

At first view the connexion between the forthcoming International Congress on Moral Education and Illumination would seem to be somewhat remote; and yet, so all-pervading are the indirect effects of the conditions of illumination under which we live, that it may fairly be said that good lighting is an absolute essential from the moral standpoint.

A very close association can be shown to exist in our minds between darkness and evil. This is exemplified in our modes of speech when we speak of "dark deeds," the "Prince of Darkness," the "Powers of Darkness," &c. The fear of the dark which is deeply implanted in the mind of almost every child is possibly but another manifestation of the same instinct, and it is a familiar method—and many would consider a foolish and cruel method—of punishing a child to shut it up in the dark. It may, indeed, be suggested that the knowledge that the terrifying darkness can be easily and immediately displaced by merely turning a switch must exert a distinctly encouraging influence upon the mind of a child, and generally stimulate its confidence.

A very obvious and practical aspect of the question is furnished by the well-known influence of good street-lighting, which is recognized by the police to have been of incalculable service in diminishing crime, by diminishing the possibilities of concealment. So well is this recognized that in many cases the police have exerted a powerful influence in problems of street-lighting and in decisions regarding all-night lighting, &c. It is common advice to those leaving their house shut up without a caretaker to leave a few small lights burning continuously as a preventive against burglary.

But it seems justifiable to draw more general deductions than this as to the effect of inadequate lighting. It is a recognized fact that where only a miserable dim illumination is possible dirt and disease accumulate, rendering it virtually impossible for those living under its influence to live a wholesome life. Quite apart from this, too, continual darkness is apt to cause people to become careless about matters which they would be ashamed to neglect in the light of day. Besides, inefficient illumination has occasionally led to tragic mistakes; there are cases on record in which the contents of a bottle of poison have been drunk by mistake, simply because it was taken for granted in the darkness that the bottle sought for was in its accustomed place.

Probably, however, the sheer *ability to conceal* arising from the presence of imperfectly illuminated regions has in itself an indirect influence upon moral character. A person about to do something that he knows, or suspects to be wrong, involuntarily chooses the darkness for his act, and it may legitimately be inquired whether the habitual and involuntary association of the dark conditions with the possibility of undetected wrongdoing does not in itself predispose towards evil.

Especially is this true of children. When a child is engaged upon some mischievous act, however trifling it may be considered to be, he goes away into some dark corner to do it; in such a case we may look upon the darkness, and especially darkness that can only be dissipated with some effort or inconvenience, as a temptation. Even in the schoolroom the system of illumination has a very distinct influence upon the ease or difficulty of the teacher's task, from this point of view alone. If there exist ill-lighted corners in which he cannot clearly see what the children are doing, they soon become a centre of disturbance.

And lastly we cannot afford to neglect what is often regarded as a very potent

moral force, namely the estimation in which we are held by others. This influence is proportionally weakened in conditions in which the sense of sight, one of the senses by which we gain information about each other, is seriously handicapped. This is, of course, particularly true of personal habits of cleanliness, &c., but it is also true of habit in general. Broadly, the impossibility of securing good illumination at will must tend to exert an unfavourable influence by weakening one of the links which connects individuals and facilitates intercourse between them.

Photometry in Central Station Testing.

(H. A. Ratcliff, A M.I.E.E., paper on 'Work and Equipment of a Testing and Standardising Dept.,' Nottingham Convention, 1908.)

THERE is no doubt that the sooner every electricity department is equipped with a reasonable amount of photometric apparatus the sooner will the results obtained by the use of such equipments reveal the absolute necessity for further improvement of the existing methods for converting electrical energy into light. Money is therefore well spent on photometric apparatus.

A Novel Type of Decorative Glow-Lamps.

WE notice in a recent number of *The Electrical World* of New York an interesting illustration of the application of electric glow-lamps to purely decorative purposes.

These lamps are made to imitate various fruits: strawberries, oranges, pears, &c., and are then distributed among the foliage of corresponding baskets and trees, and yield a gentle diffused glow. The wires in all such decorations are concealed in the trunks and branches of the various trees, and the contents of the tree can be supplied with current by a single plug contact. Outfits of this kind are in great demand for Christmas trees, and for decorative use in clubs, restaurants, &c.

It is interesting to notice how incandescent lamps are finding application for purely decorative purposes quite apart from their use for illuminating. It is stated that very pleasing effects can be attained by the use of the ingenious device here described, and it is quite possible that in the future the management of light in this way will form one of the most powerful weapons in the hands of the artist or decorator.

One point, however, that must be realized in all such cases is that the criteria by which the effect is judged are quite distinct from those operating in the case of lights used in the ordinary way to *illuminate*, and that restraint must be exercised in the amount of light employed. One would suppose that in such a case as that above, for instance, in which the eye is intended to look straight at the source of light, the designer must be content to allow a considerable loss of light if artistic requirements demand it, and to aim at securing a soft and pleasing glow rather than glitter and sparkle.

SPECIAL SECTION.

Some well-known Photometrical Laboratories.

II. Photometry at the National Physical Laboratory.

By Clifford C. Paterson and E. H. Rayner.

The development of work and equipment at a National Photometric Laboratory is so intimately bound up with the question of light standards and the methods of interpreting them into convenient forms of substandards for everyday use, that no apology should be needed here for entering with considerable minuteness into the details of the practice which is being followed at the National Physical Laboratory in connexion with this work. We propose to divide the description of the Photometric Section into two parts: (1) That dealing more especially with standard work; (2) that connected with the more ordinary testing of lamps. It is a matter of regret that up to the present moment it has not been possible to undertake much in the way of equipment for that more romantic branch of photometric work which entails the use of globe photometers and integrators of the Matthews or Russell-Leonard patterns for the measurement of lights of high candle-power. Nor, unfortunately, has the photometry of gas lights as yet been

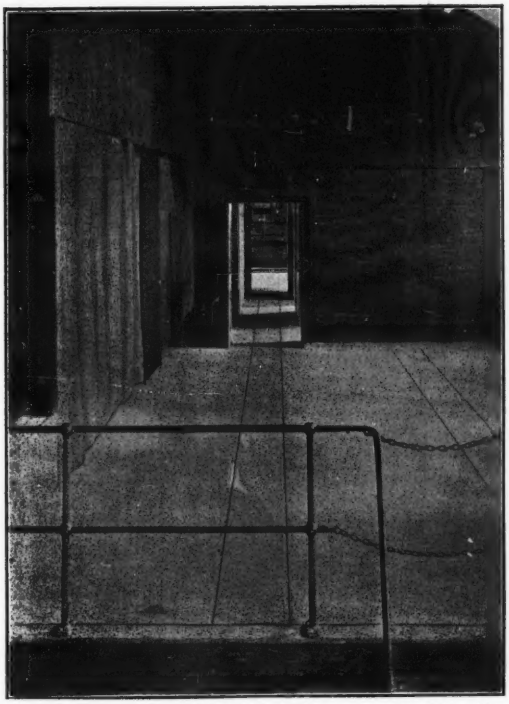


Fig. 1.—View on First Floor of Photometric Laboratory showing 90 ft. Photometer Track.

developed in a manner which will ensure relatively the same high order of accuracy as has been attained in the case of electric lights. It has rather been the policy since the department was initiated in 1903 firmly to establish the question of standards on a sound basis, devoting such funds as were available to the installation of apparatus which would enable these to be used and repeated to a very high degree of accuracy. The opening of new buildings partially devoted to photometric work in 1906 gave much greater scope than the somewhat cramped quarters first occupied, and the department now has a total floor area of over 4,000 square feet.

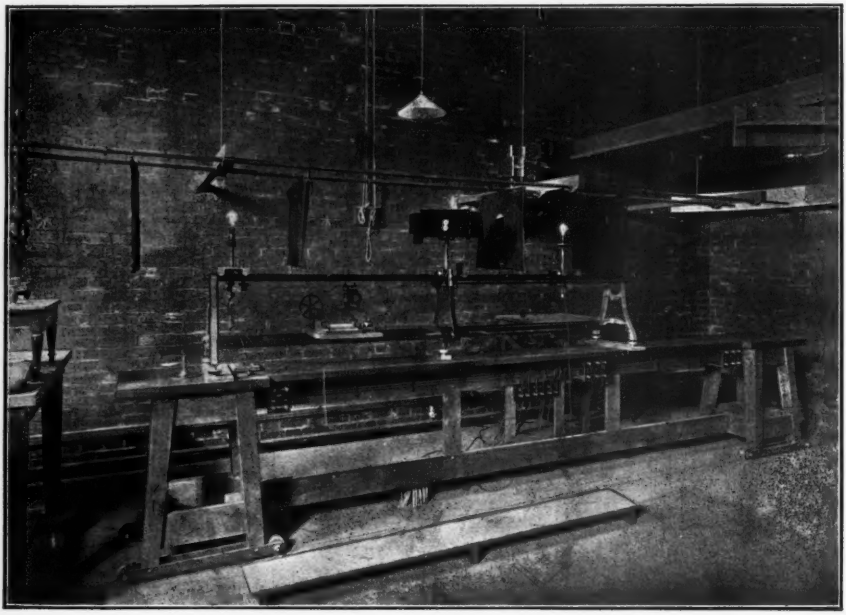


FIG. 2.—View of Photometer Bench in Standards Room.

Buildings.

The Photometric block is 90 ft. long and 25 ft. wide, with ground and first floors. The windows have been made small, and are placed high up in the rooms, so as to give, inside the rooms, a maximum amount of useful wall area in cases where a large amount of natural illumination is not required. The ground floor has been set aside chiefly for life-test work and repetition photometry. The first floor has a large room for arc lamp and similar testing, an office and workshop accommodation, and a room set aside chiefly for standard work. The test rooms on this floor average 18 ft. high. It will be seen from a photograph taken on the first floor (Fig. 1) that the gangway along the centre enables a photometric track to be employed which is virtually 90 ft. long. It is, of course, impracticable to have the ordinary photometer bars this length, but a rail track has been laid along the gangway, and by mounting on rollers the long tables which carry the photometer benches (see Fig. 2) it is possible to move them to different fixed points and employ the ordinary 2 or 3 meter bars for fine adjustment. It is not of course, likely that the long track will be in continual use, but it is

expected to prove valuable for the investigation, for instance, of Purkinje effects, and for the measurement of the distribution of illumination over the beams from parabolic reflectors, or similar apparatus where the candle-power is very high. This work is at present prospective and has not yet been initiated.

Standard Work.

A view of the Standards Room is given in Fig. 2. The bench and measuring apparatus in this room are used for all work in which the highest accuracy is required, such, for instance, as the intercomparison of flame standards or the standardization of glow-lamps for electric sub-standards. The walls are entirely blackened, and all lights or reflections are carefully screened from the observer's eyes. The highest accuracy aimed at in the measurement of the candle-power of electric sub-standards, say, for instance, in the case of international comparisons of light standards with other laboratories, is one part in 1,000. This last figure can only, of course, be written small, and must be taken from the average of a good many observations. The lights to be compared must also be very nearly of the same colour. In order to obtain the last figure, voltage measurements must be correct to about one part in 10,000—so that the greatest care is necessary in the use and checking of the electrical measuring apparatus. The latter consists primarily of a Crompton Potentiometer for current and voltage measurement, and also a reflecting electrostatic voltmeter with a scale at 12 ft. radius from the instrument, and about 16 ft. long. One volt on this scale is represented by a distance of $2\frac{1}{2}$ in. (see Fig. 3). This instrument must be calibrated from time to time at the point of use, against the potentiometer, in order to allow for a slow upward creep which takes place, due to the elastic fatigue of the suspension.

It will not perhaps be out of place here to describe in detail the method used for the ordinary measurement of candle-power, and to point out the various photometric errors which have to be avoided in connexion with this work. The most obvious method of comparing lamps, and that which is often described in elementary text-books, is to set up a standard lamp at one end of the bench and the test lamp at the other. A point is found somewhere between them at which a Bunsen, Lummer-Brodhun, or similar photometer head shows a balance, and the candle-power of the test lamp is deduced from the standard by taking the ratio of the squares of the distances. This method, however, is liable to several sources of error.

1. Photometer screen error.
2. Zero error of photometer head.
3. Unequal reflections from extraneous objects at the two ends of the bench.
4. Observer's personal error.

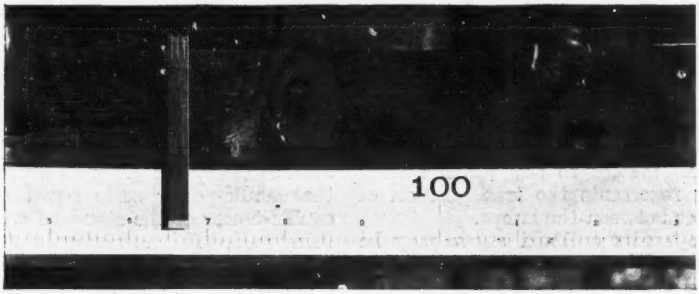


FIG. 3.—Portion of Wide Scale Reflecting Voltmeter from 95 to 103 Volts, with 6 ft. rule to give relative size.

Under 1, it is common knowledge that a photometer screen must be reversed, in order to eliminate the inequality of the two sides. It is often supposed, however, that the reversal of the screen is a panacea for all the troubles. As a matter of fact it only cures errors under the first heading and leaves the others untouched.

2. The zero error of the photometer head is large or small according as the pointer which runs over the scale is much or little out of the true centre line of the photometer screen.

3. For work requiring great accuracy care is needed in guarding against reflections from the screens which are put up to shield the photometer from extraneous light. Even velvet reflects or diffuses some light, and the same amount may not be reflected at both ends of the bench.

4. The fourth and usually the largest error is the personal one. One observer consistently sets either higher or lower than another, and it is a difficult matter to say which setting really represents the true position of balance between the lamps.

The errors outlined above may be eliminated by two methods. Either a second set of readings may be made with the position of the lamps interchanged, and the average taken—or a substitution method may be employed. The former is often useful when flame standards are being compared, the latter is nearly always preferable for the measurement of electric lamps, whether the measurements are wanted to a standard or to a commercial accuracy.

The exact substitution method which is employed for general work at the National Physical Laboratory is carried out on benches in which it is possible to clamp the right-hand lamp-carriage to the photometer carriage by means of an adjustable bar. A standard electric lamp of known candle-power is first fixed at the left-hand end of the bench. The scale of the bench is divided in millimeters the whole length, and a square law scale is also engraved on it. The main divisions of the square law scale are arranged so that at a point on the bench above any given division, there is an illumination of 10 candle meters when a lamp of candle-power equal to the number of the division is placed on zero at the left-hand end of the bench. Thus, suppose we have a standard of 13·5 candle-power

$$\text{Illumination, } I = \frac{CP}{d^2}$$

$$I = 10 \text{ candle meters.}$$

$$\therefore d = \sqrt{\frac{13{\cdot}5}{10}} \text{ meters} = 1{\cdot}162.$$

Hence opposite the reading 1·162 mm. on the one scale there is a division marked 13·5 candles on the other. The lower scale is thus graduated from 0 to 90 candle-power in a 3 meter bench. A "comparison lamp" (that is to say a lamp of suitable colour and voltage, but of no particular candle-power) is fixed on the right-hand carriage. This lamp merely serves as a temporary sub-standard for transferring from the standard to the test lamp. The photometer head is clamped rigidly at a point on the candle-power scale equal to the candle-power of the standard which is being used. It is now known that there is an illumination of 10 candle metres on the screen. The comparison or reference lamp is now moved nearer or further from the photometer until an exact balance is obtained. At the point of balance the connecting bar between this carriage and the photometer head is firmly clamped, and the photometer carriage being unclamped from the bench, the two saddles move together with a definite fixed distance between them. It is desirable to note this fixed distance on the millimeter scale and set up one or two other standards, repeating the process in order to see if the fixed distance always comes out the same. Having finally decided from several standards what the fixed distance should be, the clamping bar is finally adjusted, and the test lamps are set up one after another in the place of the standards. With any test lamps, wherever the point of balance is obtained, the candle-power is read off direct on the square law scale, without

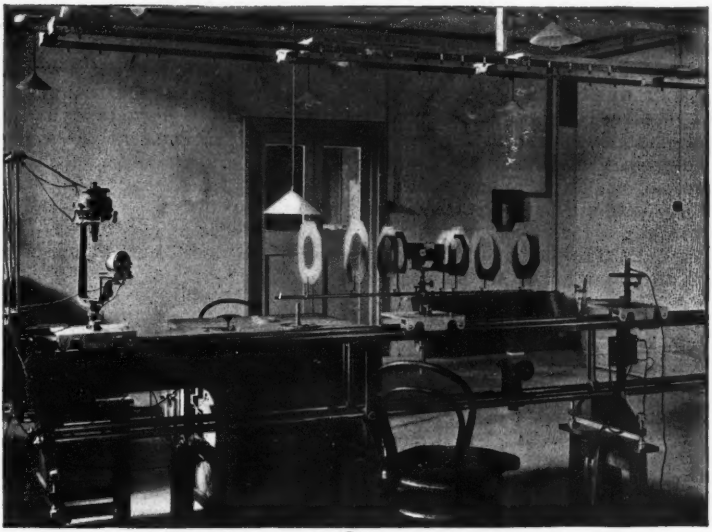


FIG. 4.—Photometer Bench for Life Tests on Glow Lamps (screens partially removed)

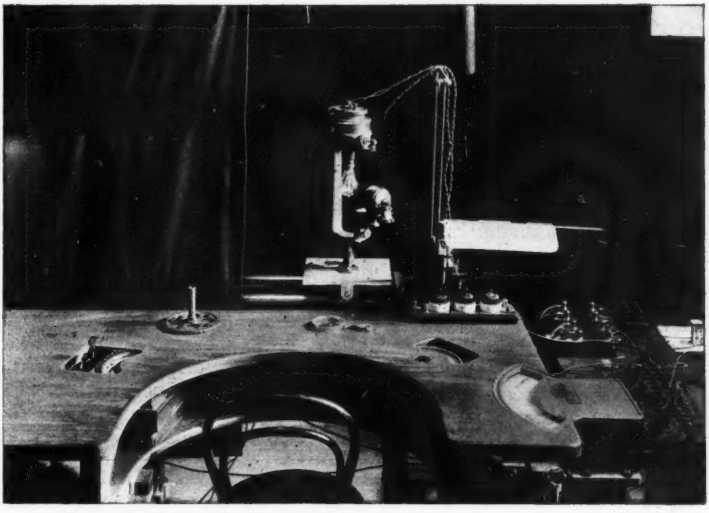


FIG. 5.—Table with Measuring Instruments for Bench shown in Fig. 4.

any calculation being necessary. It will also be appreciated that by such a substitution method all the errors mentioned earlier are for practical purposes eliminated. Errors due to judging wide differences of colour are not, of course, entirely eliminated by this method, but there is an opportunity of avoiding serious errors due to this cause, by choosing a comparison lamp the colour of which lies midway between those of the two sources to be compared. The colour difference between any two lights to be compared is thus halved for any setting. Lummer-Brodhun photometers of the contrast type are used for all ordinary work, and, as far as the authors' experience goes, although only one eye can be used in the observations, the latter are less tiring and more accurate than those with other instruments which have been tried. In their opinion one observation with a Lummer-Brodhun head (contrast type) is equivalent to two or three with a Bunsen or other similar type where the object is to obtain merely equality of illumination over a surface.

Before leaving the subject of comparison of standards, it should be mentioned that the observer at the photometer head never sees his own readings until they are all taken and entered up, so that he has no chance of being unconsciously biassed in one direction or another. His only business is to sit at the photometer and take none but photometric observations. Standardizations of glow-lamps are never completed in one set of readings, but the lamps are put up and standardized on three or four separate occasions. By this means it is possible to determine the candle-power of good electric standards to an accuracy approaching 2 parts in 1,000.

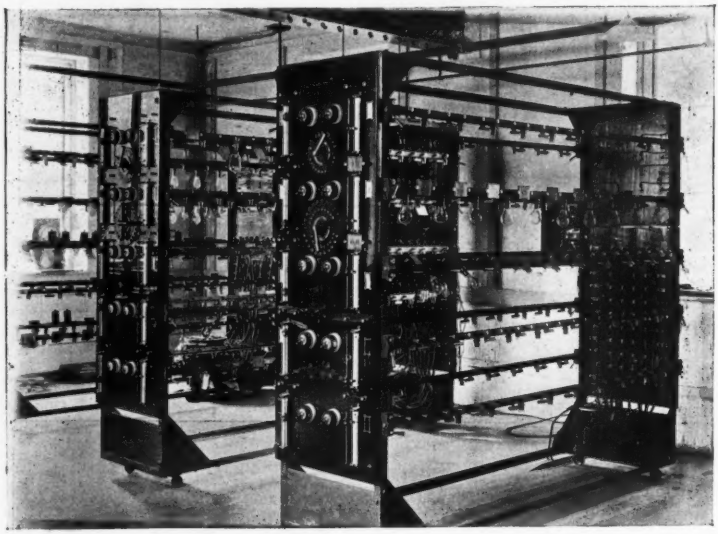


FIG 6.—Racks for Life Tests on Glow Lamps.

Life Tests on Glow-Lamps.

A further branch of work which is now fully developed is the testing of glow-lamps for useful life.* There is hardly space in an article of this description to discuss the advantages

* The "useful life" of an incandescent lamp is taken to be the number of hours required before the candle-power falls below 80 per cent of its initial value.

and disadvantages of various forms of life tests on glow-lamps. All kinds of tests are, of course, carried out, but that which is most systematized is the test to the Engineering Standards Committee's Specification.

The question of initial tests on a batch of glow-lamps is a simple matter. 5 per cent of a consignment is put through the photometers and tested for candle-power and watts at rated voltage. The values found are plotted on a target diagram which shows at

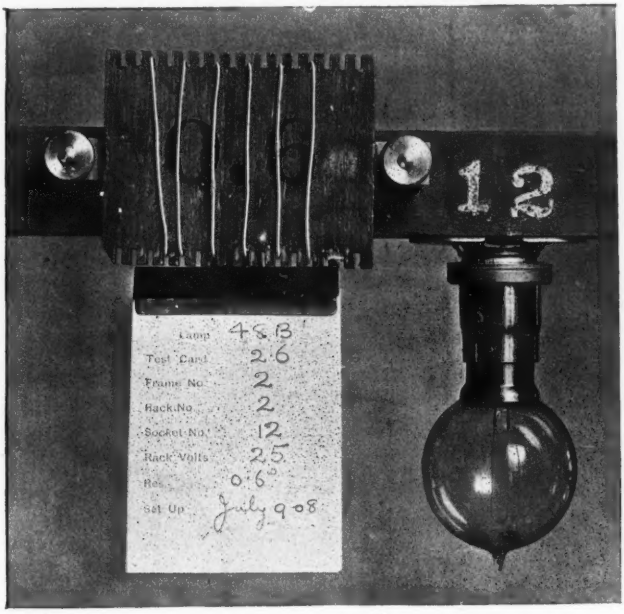


FIG. 7.—View of Life Test Lamp, Resistance and Card as fixed on the Racks.

once how near the selected lamps fall to their rated value.*

The matter of life tests, however, requires more than commercial accuracy. The photometer work is semi-standard and necessitates making electric measurements to a higher accuracy than 1 part in 1,000. A similar degree of accuracy is required in the adjust-

* A target diagram is one in which the ordinates are proportional to the candle-power of the lamps, and the abscissæ to the watts consumed.

ments of pressure during the life test. It is not always appreciated that for a 100 volt carbon filament lamp running at 3·1 watts per candle the useful life varies approximately as the twentieth power of the voltage, and as the sixth power of the watts per candle. It is for this reason that it is useless to pick out one or two lamps at random from a batch and run them at normal voltage in order to see what life they give. The only really satisfactory method of testing whether or not a filament is of high-grade quality is to set it up on a life test at some definite value of watts per candle at which it is known that good filaments will give a certain length of life. Such a table of watts per candle is given in the Engineering Standards Committee's Specification on Carbon-filament Glow-lamps. For instance, a 16 candle-power 110 volt lamp should give a 400 hours useful life if set up at 3·1 watts per candle. The same lamp should burn 800 hours if started at

3·5 watts per candle. For a 220 volt lamp the corresponding figures are 3·7 and 4·1. The method of testing at definite watts per candle has the advantage that it is only necessary to test a very few lamps out of a consignment for life. (The E.S.C. Specification gives 5 out of 2,000, as a minimum). A photograph of the bench (made by Messrs. Alex. Wright & Co.) on which life test measurements are carried out is shown in Fig. 4. The principle of photometry which is employed is the same as that described earlier in this article.* The electric measuring instruments are shown as installed in Fig. 5, and are all of the direct deflection type. They consist of a large laboratory precision voltmeter made specially by Messrs. Elliott Bros., and a special compensated wattmeter and voltmeter by Siemens & Halske, enabling watts to be read direct without an additional correction for the current taken by the voltmeter or the volt coil of the wattmeter. The bench measurements are all made with direct current from a 300 volt battery installed for the purpose. The measurement of the candle-power of lamps at intervals during the life test is, of course, a simple matter. In order, however, to find the exact volts at which a lamp is giving its correct watts per candle, it is put into the bench and measured three times, the correct voltage being found by successive approximation, special numerical difference tables having been made out to accelerate the operation.

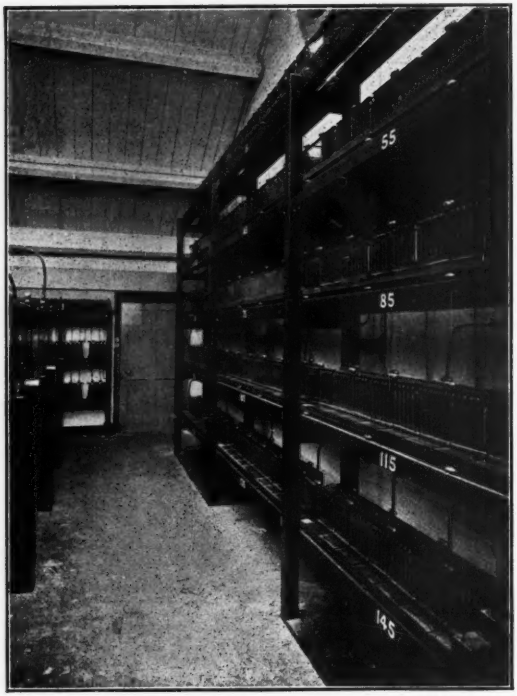


FIG. 8.—Battery for Photometric Work.

* Special screening arrangements have been installed, and are partly illustrated in the figure. They enable the photometer bench to be used in a room with ordinary whitened walls without fear of external light affecting the observations.

Having found the correct volts, special arrangements have to be made to ensure that this is the voltage at the terminals of the lamp throughout the life test. For this purpose life test frames, illustrated in Fig. 6, have been constructed at the Laboratory. The lamp sockets are fixed at 8 in. centres on iron angles which can be rotated so as to enable lamps to be supported either in an upright, pendant, horizontal, or any other position. An alternating current of 55 cycles and 240 volts feeds an auto-transformer connected to each rack. A large number of tappings from the transformer enables any pressure to be obtained in steps of 5 volts. A number of independent turns enable additional 1 volt and 2 volt steps to be added, so that it is only necessary to use a small resistance in series with any rack. The lamp sockets are arranged ten to a rack, there being 10 racks to each frame. The voltage at which a lamp has to be run being usually slightly different from all the others in the rack, it is necessary to arrange that a resistance can be inserted in series with each lamp to make up for the difference between the rack volts and the lamp volts. This amount is usually something under one volt. Some 2,000 resistances have been made up for this purpose, varying by tenths of an ohm from 0·1 up to 5·5 ohms. They consist simply of lengths of Eureka wire wound over

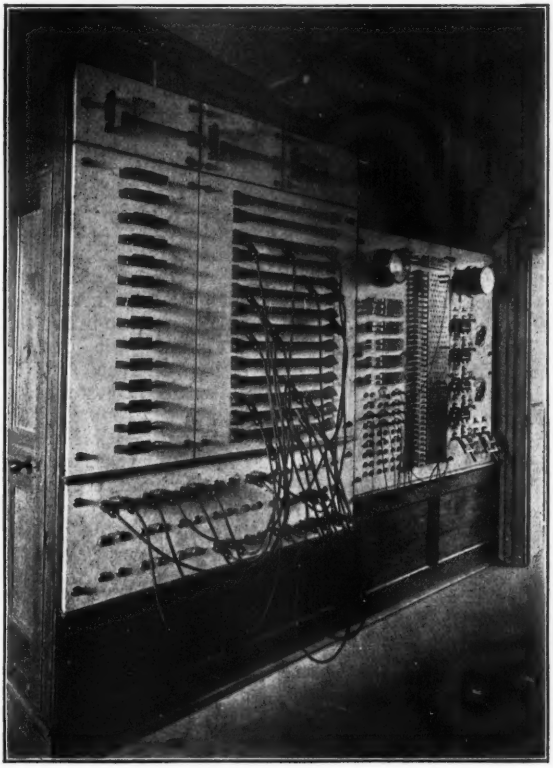


Fig. 9.—Distributing Panels, Photometric Laboratory.

wooden combs, the ends of the wire being brought to brass connecting tags which clamp up under the terminals provided on the racks for the purpose. A view of the whole arrangement is shown in Fig. 7, and is simlar in its general design to that installed at the Electrical Testing Laboratories in New York.

The controlling panel shown in the front of the frame in Fig. 7 has a selector switch for putting a voltmeter across any one of the racks. The voltmeter is a large type instrument by Elliott Bros., which has been specially designed for the purpose, and which is kept checked against the laboratory standards. A difficulty arises in using an instrument of this type, which takes current, since, if there happens to be only one lamp in a rack, in series with which is a regulating resistance, the current taken by the voltmeter (being comparable with that taken by the lamp) causes the voltage at the lamp terminals to be lower when the voltmeter is in circuit than when it is disconnected. Hence the lamp will be somewhat overrun on the life test. To obviate this a number of resistances have been made up equal to the resistance of the voltmeter. One of these is always across each of the racks when the volts are not being measured. The selector switch is arranged so that at the same time as the voltmeter is put across a rack the dummy voltmeter resistance is open-circuited, so maintaining the current constant through the rheostat in series with that rack.

The alternating voltage for the lamps on life test is automatically maintained constant by means of a Tyrrill Regulator, which maintains the pressure well within the limits of plus or minus one half per cent.

The battery chiefly used for photometric work is illustrated in Fig. 8. It consists of 150 cells by the E.P.S. Co. of 45 amp. hour capacity. Tappings are brought down from this battery to a distributing board on the landing of the photometric section (see Fig. 9 right-hand board). There are tappings every 10 volts from the battery, with 4 volt sub-divisions at the ends, enabling any desired voltage up to 300 to be obtained in 4 volt steps. The tappings are brought to horizontal bars behind the ebonite protective covering on the switch-board. The circuits, 23 in number, from various points in the rooms, terminate in plug sockets on the left-hand lower panel. By means of these sockets any desired connexion can be made by means of flexible leads to the battery bars. The switches, &c., on the right-hand panel are merely arrangements for charging sections of the battery alone.

An International Hint of Candle-power.

As will be seen elsewhere in this issue Dr. Glazebrook has communicated to the British Association a note of considerable interest as regards the present movement towards simplifying the hitherto accepted relations between the units of light in different countries.

It has been recently proposed by the National French Committee of the Electrotechnical Commission that the British candle should be raised 2 per cent, and the United States candle lowered 2 per cent, while the French candle is maintained at its intermediate value, thus bringing the three units into supposed practical agreement. Under these circumstances the Hefner unit would still, of course, differ very widely from the common unit, and it would perhaps be too much to expect Germany to make the inconveniently large change required to fall into line. She would, however, at least benefit by the proposed arrangement to the extent of there being *only two* existing units in use in future.

However, naturally, the recent communication from the National Physical Laboratory, according to which the relations up till now regarded as correct between the British and the foreign units require modification, entirely alters the aspect of affairs, and it is possible that a different decision may now be adopted.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

The Effects of Ultra-Violet Light on the Eye.

(Discussion of paper by Drs Schanz and Stockhausen, read before the Verband Deutscher Elektrotechniker, June 12th and 13th; abstracted from the *Elektrotechnische Zeitschrift*, August 27th).

THE paper by Drs. Schanz and Stockhausen, abstracted in the September number of *The Illuminating Engineer*, gave rise to a most animated discussion, fully confirming the opinions expressed by several speakers as to the importance of some of these physiological questions to the engineer.

HERR AXMANN opened the discussion, and corroborated the effect of severe exposure to ultra-violet rays on the eyes. When working with the Uviol lamp at the glass-works in Jena, he and other workers had at first supposed that ordinary window-glass offered sufficient protection. But the resulting inflammation of the eyes soon convinced them of the contrary. As a result of spectroscopic investigations they had evolved a glass that answered the required purpose. The speaker exhibited a specimen; it was not green nor yellow in appearance, but rather of an orange tint. It did not, however, interfere with ordinary vision when the wearer became accustomed to its use. This glass was specially devised to prevent the passage of rays in the neighbourhood of 400 $\mu\mu$, which he agreed with Dr. Schanz in considering the most dangerous.

In ordinary circumstances, however, the effects of ultra-violet light were not serious; they even exerted a beneficial action on some eyes. In this connexion the speaker mentioned the case of a lady who suffered from a form of cataract so severely that it was necessary to lead her to the chair on which she sat. Yet after treatment with ultra-violet rays she recovered her sight sufficiently to be able to walk about in comfort.

HERR HERAEUS remarked that one matter of great interest not studied by the authors was the comparison of the strength of ultra-violet radiation in daylight and in artificial illumination; very possibly diffused daylight was at least as rich as artificial sources in this way.

HERR HAAGN followed up this suggestion by describing some experiments which showed that the rays of the sun, like those from the quartz-lamp, contained a considerable amount of radiation near 400 $\mu\mu$. Although numerical comparison was admittedly difficult, he hardly thought that the human eye, which had become accustomed to daylight for thousands of years, could be so easily injured by ultra-violet light as Dr. Schanz seemed to fear. In any case practical experience was the only guide.

DR. KÜCH, the inventor of the quartz-lamp, had, indeed, initially suffered from inflammation of the eyes, but, subsequently, by the use of suitable glass screens, and by screening all stray light, he had been able to experiment with the lamp during a period of several years without experiencing any diminution in visual acuity or other evil results.

DR. ZSCHIMMER stated that he had worked in co-operation with the Ophthalmological Hospital and Medical School of Jena, and had come to the conclusion that the whole question required further exact study, and was not as yet ripe for discussion. In particular he had remarked that physiological experiments were rarely accompanied by the necessary quantitative data as to the intensity the light, &c.

There could be no doubt of the inflammation caused by exposure to sources very rich in ultra-violet rays; on the other hand, he thought that it was rash to conclude from this that the ultra-violet light in ordinary sources of light—glow-lamps, incandescent mantles, and so on—was to be regarded as a source of danger. He specially deprecated hasty conclusions on the matter, because these were liable to be taken up and exaggerated in the non-technical press, with the result that the general public became unreasonably nervous.

HERR BLAU expressed his agreement with the suggestion of Herr Heraeus with regard to the desirability of a comparative study of the ultra-violet element in day-

light and artificial illuminants. (It is interesting to note that since this discussion a paper by W. Voege on this aspect of the subject has been published: see *The Illuminating Engineer*, September.) If ultra-violet light were really injurious it would seem as necessary to make window-panes of specially absorbing glass as to make lamp-globes of such a material.

He found it very difficult to credit the statement that the "euphos" glass only absorbs 3 per cent of the visible rays; the percentage seemed more likely to approach 30 per cent.

Herr Axmann described the influence of the atmosphere on the quality of the sun's rays. Before reaching us, the short waves present in such radiation were very largely absorbed by the atmosphere. Thus it came about that in the mountains, at a height of, say, 1,000 metres, the light produced special effects, that were absent on the horizon.

In meeting such exceptional conditions, glass opaque to ultra-violet light might be very necessary: he, himself, when working with ultra-violet light and using blue glasses, had suffered from inflammation of the eyes; but the use of the special Jena glass had completely relieved him of the trouble. Even the newest and most powerful sources, however, such as the Uviol and quartz lamps, were not very dangerous when comparatively distant from the eyes. Thus at a distance of 1·30 to 1·50 metres the rays are absorbed by the air to such an extent as to cease to be really effective. The *very* short waves are absorbed even in distances of 1 to 2 centimetres.

Only specially sensitive or sick people required protection for the eyes when subjected to diffused illumination from such lights.

Herr Breslauer referred to the fact that blue glasses were of actual benefit in protecting the eyes from snow blindness. Yet such glasses have been described as quite ineffective for the purpose of obstructing the passage of ultra-violet rays. How was it possible, therefore, to reconcile this statement with the contention that snow blindness was due to the action of these rays?

Herr Zschimmer replied to this question. He quoted Prof. Hertel of Jena as his authority for the statement that the trouble with the eyes experienced at high altitudes was probably mainly caused by certain of the visible rays, the yellow, green-yellow, and blue light, though the ultra-violet light also contributed slightly.

Herr Zschimmer also referred to the difficulty of making a suitable variety of glass opaque to ultra-violet light. The glass exhibited by Herr Axmann was really intended for photographic purposes merely. What was really wanted was a neutral glass, omitting only the undesirable elements, both visible and invisible. Even dark glasses allowed some ultra-violet light to pass.

Unfortunately the majority of glasses not only allowed ultra-violet light to pass, but did not exert uniform absorption, and it would be a great discovery if any one could produce a colourless glass capable of rigidly cutting off the light at the ultra-violet margin, as Dr. Stockhausen's glass was said to do. After examining hundreds of colours in the Jena glass works, they had almost come to the conclusion that such a performance demanded the discovery of a new element. All known colouring materials, instead of sharply cutting off the spectrum at a certain point, gave curves of gradually increasing absorbtion, and even so the elimination of ultra-violet light was only attained by the sacrifice of 20 to 30 per cent of the useful visible light.

However, the subject was receiving more and more careful study at the hands of physiologists, and he would not fail to bring this discussion before the notice of those at work in Jena, in order that their progress might be hastened.

Herr Görges regarded the present discussion as anything but superfluous, and thought it very gratifying that these questions were at last being threshed out. He had recently come across the statement in a newspaper that "the ordinary glow-lamp was simply poison to the eye." Such statements naturally caused much disquiet to the general public. It was fully time that we inquired into the matter and ascertained, definitely, whether the ordinary glow-lamp was used in an injurious way or no.

Herr Schanz, speaking with reference to the relative amounts of ultra-violet energy in daylight and sunlight, mentioned snow blindness as analogous to "opthalmia electrica," the inflammation caused by looking at the electric arc. He also referred to the work of Widmark, Schulek, Bisch-Hirschfeld, Hertel, Hess, Herzog, &c., all of whom have confirmed the injurious effect of ultra-violet light, and mentioned that, at the hygienic section of the "Naturforscherversammlung," general agreement was expressed on this question.

The essential point was that a glass was now available capable of protecting the eyes from such radiation; ultra-violet rays were an impurity in ordinary light, the removal of which was desirable from the physiological standpoint.

HERR HERAEUS considered that the existence of snow blindness in polar regions was no criterion as to the injurious effect of ultra-violet rays in ordinary daylight. As a basis of comparison between daylight and artificial illuminants, ordinary everyday conditions should be assumed, and it was desirable that spectrographic comparisons should be shown side by side.

HERR STOCKHAUSEN said that his contentions were based on exact measurement. Naturally direct sunlight and light from the blue sky contained ultra-violet light, but very little of this arrived at the eye in the case of diffused (and reflected) daylight, by which ordinary operations were carried out.

HERR BLAU and HERR HAAGN repeated their conviction that, from the point of view of ultra-violet light, diffused daylight must be considered at least as dangerous as ordinary artificial illuminants.

HERR STOCKHAUSEN dealt with some objections that had been raised as regards the times of exposure allowed in obtaining his spectrographs. He explained that the visible result in such a case depended upon the opening of the slit, the surface-brightness of the illuminant examined, the intensity of the light, and the time of exposure. Any one having experience of spectro-photography would bear him out when he stated that it was not possible to retain all these quantities simultaneously constant, though they had made many experiments varying one or other of the quantities in question.

Spectrographs were only intended to exhibit results qualitatively, as there was no existing method of obtaining quantitative results that was not open to some objection or other.

HERR NORDEN and HERR HAAGN agreed as to the difficulty of comparing daylight and artificial illuminants by existing methods: the latter, however, thought that it could be shown, at least, that artificial illuminants were no more dangerous than daylight. HERR ZSCHIMMER referred to the very exact measurements of Prof. Hertel.

Some other discussion on the possibility of exact quantitative measurements, by Herr Blau, Herr Retschinsky, and Herr Stockhausen (who considered the method of Prof. Hertel unsatisfactory) followed.

HERR TEICHMÜLLER regarded the discussion as very valuable, and thought there was a danger of engineers erring in the direction of making the *visible* intrinsic brilliancy of illuminated signs, &c., too bright. He thought that there was also room for advice from physiologists as to the desirable limit of brilliancy. The journal might not be so absolutely wrong in asserting that "electric glow-lights are poison to the eye," and the careful study of these questions by engineers was much to be desired.

Further Comments on the Subject.

Since the publication of the above discussion, a letter from Prof. Blondel has appeared in the *Elektrotechnische Zeitschrift* of Sept. 24th, putting forward an interesting suggestion.

Prof. Blondel, from his own experience, is inclined to believe that artificial light may prove to be more tiring to the eyes than daylight, notwithstanding the fact that the latter may contain a stronger ultra-violet element. This may be explained on the supposition that the eye, when using artificial light, is in general using a lower order of brilliancy altogether than in the daytime, and is therefore in a different physiological condition.

At this relatively low illumination the "rods" in the eye play a more important part than in the daytime, when our vision is mainly accomplished by the "cones"; hence it may be that in this condition they are more susceptible to the fatiguing variety of light.

Prof. Blondel states that he himself has suffered from inflammation of the eye, and during his recovery found he was able to read in comfort by daylight, when he was unable to do so by the aid of artificial illuminants. Subsequently he found that he was able to read by the light from a glow-lamp run at a consumption of 3·5 watts per candle, but that the light from a lamp taking 2·5 watts per candle proved too fatiguing, and he therefore supposes that this difference was due to the greater proportion of short wave-length energy in the latter case.

Recent Developments in Electric Lighting.

By W. Wedding.

(Paper read at the Annual Meeting of the Verband Deutscher Elektrotechniker, abstracted from the *Elektrotechnische Zeitschrift*, July 30th, 1908.)

This paper gives an account of the present state of electric illumination, and describes a series of elaborate tests on a number of the most recent types of incandescent lamps with metalized carbon, Tantalum, and Wolfram filaments respectively.

These lamps differ both as regards materials used and methods of manufacture, and have, therefore, been classified by the author in three distinct classes. The actual number of lamps, in each case grouped accordingly in the three classes, was as follows:—

First Class—Metallized-Carbon Lamps.

Ten 16 H.K. lamps for 107 volts.
Ten 50 H.K. lamps for 110 volts.
Ten 25 H.K. lamps from the A.E.G.

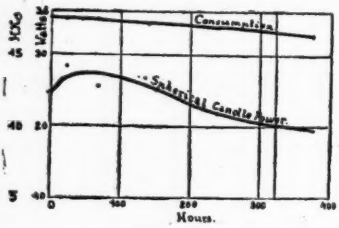


Fig. 1.

Second Class—Tantalum Lamps.

Twelve 16 H.K. lamps, twelve 25 H.K. lamps, and five 50 H.K. 110 volt lamps from Messrs. Siemens & Halske.

Third Class—Wolfram Lamps.

Forty-nine 25 H.K. lamps, thirty-six 32 H.K. lamps, fifty-four 50 H.K. lamps, eight 100 H.K. lamps are for 100 volts, and also one 32 H.K., twenty-three 50 H.K. and four 100 H.K. 220 volt lamps.

The majority of lamps were tested on a voltage fluctuating considerably, but there was no possibility of their being subjected to shock, except when they were put in and replaced. During the first test all the lamps were burning in a downward position, and the horizontal intensity was measured. Afterwards, every lamp was put into the globe photometer, in order to determine the mean spherical candle-power in each case, and thus to enable a comparison of the lamps under equal conditions to be made. All other photometrical measurements were made by the aid of the globe photometer.

Class I.—Metallized Carbon Lamps.

The advantage claimed for these lamps is based on the fact that the filament, in contradistinction to that of the ordinary carbon lamp, possesses a positive temperature co-efficient, and the author gives several diagrams illustrating this property.

In Figs. 1 and 2 are given the results

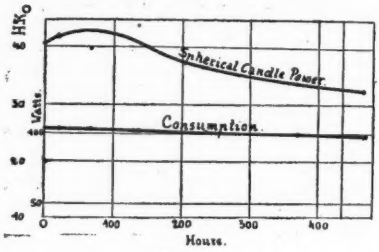


Fig. 2.

of some life tests, showing the decrease in consumption and candle-power during life.

Class II.—Tantalum Lamps.

As regards efficiency the tantalum lamp seems to be more favourably placed than the metallized filament lamp, but on the other hand the cost price of the metallized carbon lamp is the lower of the two. Only time can show what part is to be played by these two classes of lamps in the lighting industry in the future. There can, however, be no doubt of the importance of obtaining a lamp which is both efficient and able to withstand shock.

One point remarked upon by the author is that the useful life, and the period of

TABLE I.

Nature of Lamp.	Initial Candle-power. Horizontal H K.$_h$	Initial Candle-power. Spherical H.K.$_0$	Initial Consumption.	Watts per H.K. Horizont'l W/H.K.$_h$	Watts per H.K. Spherical W/H.K.$_0$	Reducing Factor. $\frac{H.K._h}{H.K._0}$	Useful Life.	Average Consumption. Watts.	Mean Spherical Intensity. H.K.$_0$	Mean Watts per H.K. W/H.K.$_0$	Average Time in Hours before first Breakage of Filament.	Number of Lamps Tested.
Metallized Carbon	16·8	13·34	35·14	2·09	2·63	1·257	322	34·2	12·02	2·85	—	10
	52·9	40·2	102·9	1·95	2·56	1·31	434	100·7	37·7	2·66	—	10
	24·3	17·8	55·0	2·26	3·09	1·365	733	54·7	17·2	3·18	—	10
Tantalum ...	15·1	11·6	26·1	1·73	2·26	1·300	867	27·3	13·1	2·09	769	12
	23·1	17·5	39·7	1·72	2·26	1·315	1552	41·4	18·2	2·27	1493	12
	51·0	38·4	86·6	1·69	2·26	1·330	1685	85·7	38·9	2·2	1787	5
Wolfram. No. 1	26·3	20·0	28·1	1·07	1·40	1·317	1651	27·8	16·4	1·69	1651	8
2	27·1	17·5	35·3	1·30	2·02	1·549	> 1372	35·6	19·0	1·87	> 1038	5
3	27·9	20·3	30·2	1·08	1·49	1·375	665	31·0	22·8	1·36	550	12
4	27·7	18·7	29·2	1·05	1·56	1·482	—	—	—	—	—	10 (Alternating current)
5	27·9	18·9	29·1	1·05	1·56	1·482	> 867	29·0	18·3	1·59	> 867	10
6	28·5	22·8	36·1	1·27	1·58	1·248	1819	36·0	22·3	1·61	1727	10
7	30·3	21·0	48·6	1·60	2·31	1·437	669	50·7	24·1	2·10	80	1 (220 V)
8	31·5	22·4	30·9	0·97	1·37	1·405	> 1236	30·5	20·8	1·46	> 1236	6
9	35·3	28·7	40·0	1·14	1·40	1·23	1217	38·9	26·0	1·49	1011	10
10	36·5	26·0	39·2	1·07	1·51	1·405	> 1137	38·7	26·3	1·47	> 1060	6
11	37·5	28·2	38·8	1·03	1·37	1·327	1492	38·5	24·2	1·59	1492	8
12	50·3	36·1	56·9	1·13	1·56	1·390	> 1201	56·6	34·4	1·65	> 1201	6
13	50·8	35·8	63·8	1·26	1·78	1·415	—	—	—	—	—	6 (220 V)
14	54·2	40·8	58·7	1·08	1·44	1·330	1014	61·1	44·3	1·37	990	12
15	54·3	41·2	60·1	1·11	1·46	1·320	756	60·2	36·6	1·64	756	8
16	55·8	44·5	67·9	1·22	1·52	1·252	1111	66·9	43·8	1·53	1098	4 (220 V)
17	56·6	36·4	71·3	1·25	1·96	1·560	> 806	70·9	35·4	2·00	> 806	5 (220 V)
18	57·7	43·2	70·2	1·21	1·62	1·335	> 1142	71·0	40·5	1·75	> 1080	8 (220 V)
19	58·7	37·9	64·7	1·10	1·71	1·549	> 1732	64·6	39·2	1·65	> 1725	5
20	99·8	79·2	111·1	1·11	1·40	1·262	1766	110·5	67·8	1·63	1766	4
21	116·5	97·5	126·6	1·09	1·30	1·197	413	124·1	101·0	1·23	263	4 (220 V)

time up to the first breakage of a tantalum filament are nearly identical; after a filament has once been ruptured and welded together again, other failures usually follow one another in quick succession, and the lamp gives way altogether.

Class III.—Wolfram Lamps.

The results of the experiments on these lamps, together with those on tantalum and metallized filament lamps previously referred to are summarized in Table I. The author remarks that the results in some cases show that a certain number of the wolfram lamps issued are imperfect; they blacken rapidly, and lose 20 per cent of their original candle-power comparatively soon. This is true, for instance, of the lamps referred to in the eighth row.

The majority of the lamps, however, actually burn out before reaching the limit of useful life (*i.e.*, a drop of 20 per cent in candle-power), and the actual life is often well over 1,000 hours. On the other hand, it must be confessed that when the lamps are subjected to constant shocks, such as may occur under practical conditions, these good results may not be realized.

In summarizing the recent progress in electric illuminants, the author recognizes three main stages of progress that may be said to be now either realized, or shortly about to be.

Firstly, we have reduced the consumption of power of glow-lamps from 3·4 to 1·2 watts per H.K.

Secondly, by the aid of metallic filaments, we have produced practical glow-lamps of over 50 H.K., which can compete successfully with the smaller arc-lamps.

Thirdly we may now expect a progressive diminution in the initial cost and costs of renewal of metallic filament lamps.

Lastly Prof. Wedding considers that it would be short-sighted to assume from the present condition of glow-lamp manufacture that we ought to return to distribution at 110 volts, and that the ultimate solution of the present difficulties will be found in the manufacture of a serviceable and yet efficient 220 volt 16 candle-power lamp.

An Electric Light Moth-Trap.

ACCORDING to *The Electrical Review* of New York, the municipal authorities of Littau, in Saxony, have been putting the electric arc-lamp to a novel use.

From time to time the forests of Central Europe are said to suffer from the ravages of moths from Russia, the larvæ of which strip the trees of their foliage, and Saxony has recently been suffering from a plague of this description. The authorities have therefore erected a powerful arc-lamp equipped with a reflector and placed over a deep receptacle fitted with exhaust fans. In this way they hoped to trap and destroy large numbers of the moths, and so prevent the laying of the eggs from which the caterpillars come in such numbers.

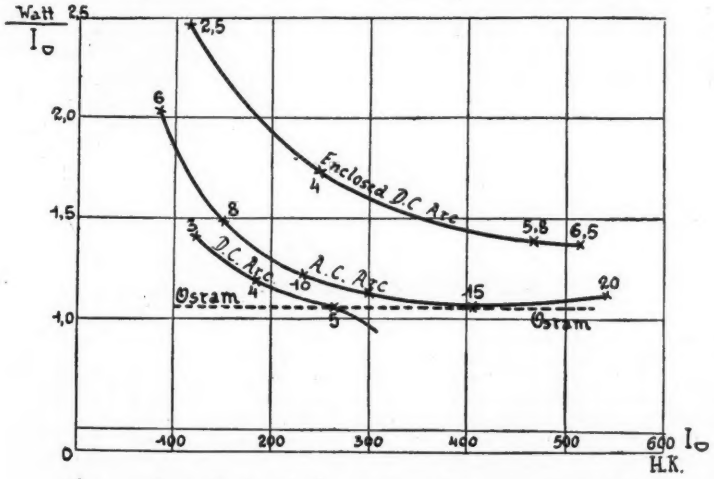
The results are said to have been amazingly successful. The moths attracted by the glare come fluttering in thousands along the beam of light from the arc-lamp, are sucked into the receptacles and subsequently destroyed. On the first night no less than three tons of moths were captured, and it has been decided to build other traps and extend the present efforts.

A Comparison of the Running Costs of Small Arc Lamps and High Candle-Power Osram Lamps.

By H. Remané.

(Paper read at the Annual Meeting of the Verband Deutscher Elektrotechniker; abstracted from the *Elektrotechnische Zeitschrift*, Aug. 20.)

Until recently two distinct types of electric illuminants were available. Each fulfilled separate functions, and was suitable for particular purposes, for which the other was inadequate. The intensity of the arc-lamps and glow-lamps on the market did not, as a rule, fall below several hundred H.K., or above about 50 H.K. respectively, and, owing to their high running cost, glow-lamps of candle-power higher than 50 H.K. had not been extensively used.



The numbers attached to the points on the curve represent the current in Amperes taken by the various arc lamps.

Fig. 1.

Some source of light intermediate in intensity between these values was therefore desirable, and this want led to the introduction of the "miniature" arc-lamps of various kinds. The Nernst lamp, with an intensity of 100 to 200 H.K., and the mercury-vapour lamp are likewise to be reckoned among illuminants in this class.

The rapid extension of such sources of moderate candle-power proved the value of a lamp ranging from 100 to 400 H.K., the initial cost of which is only about a third of that of an ordinary arc-lamp. An attempt was made to meet these conditions by cheapening the regulating mechanism of arc-lamps, but naturally the steadiness of the lamp suffered. The length of the enclosed arc being particularly adapted to this simplification, miniature lamps were mainly constructed on the enclosed plan, but their unsteady character and the colour of their light did not favour their adoption except for out-door illumination.

Nor did the Nernst lamp entirely answer its purpose, for it was only suitable for high voltages and direct currents, and very complicated in design.

As, furthermore, all the illuminants referred to had a comparatively low efficiency, the question arose, whether it would not be desirable to replace these illuminants by high candle-power Osram lamps. As the efficiency and mean

horizontal intensity of such lamps is higher than that of small and medium-sized arc-lamps in the lower hemisphere, it was anticipated that an Osram lamp giving about 400 H.K. might replace



Fig. 2.

small arc-lamps, of the same intensity. Osram lamps giving 200 to 400 H.K. have therefore now been put upon the market.

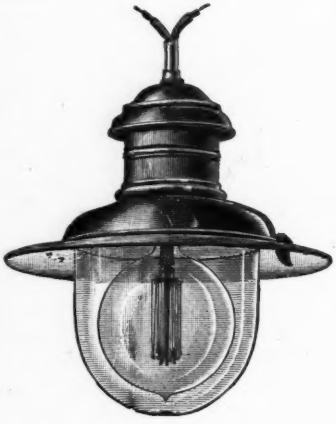


Fig. 3.

In Fig. 1 are shown some calculated figures comparing the efficiencies, as regards the lower hemisphere, of the Osram lamps and arc-lamps of different intensities.

The Osram lamp is now being made in standard sizes corresponding to 200, 300, and 400 H.K. for voltages from 110 to 130 and 200 to 250 volts, the efficiency being 1·0–1·1 watt per H.K., and the useful life on the average 800 hours.

A number of these lamps have recently been tested in the laboratories of the Auergesellschaft, Berlin, and the results obtained are shown in the accompanying tables. The mean spherical candle-power amounted to 70 per cent of the mean horizontal. Thus the mean efficiency referred to the mean spherical candle-power is 1·39 watt per H.K. The mean candle-power over the lower hemisphere proved to be 82 per cent of the mean horizontal intensity thus corresponding to an efficiency of 1·33 watts per H.K.



Fig. 4.

High candle-power Osram lamps are suitable for interior illumination, and have also been adopted for out-door use.

Standard types of these are shown in Figs. 2, 3 and 4.

In order to consider the Osram lamp and the arc-lamp under exactly equal conditions, the total running costs of both have been compared with reference to the lower hemisphere. Some results are shown in Fig. 5 and in the accompanying tables. The cost of energy has been assumed to be 45 Pf. per Kilowatt-hour for consumers deriving energy from a central station, and 10 Pf. in the case of private plants. The initial costs of the lamps are as follows :—

200 H.K.	.. ..	9 marks
300 H.K.	.. ..	12 „
400 H.K.	.. ..	15 „

With regard to the running cost of arc lamps, the cost of renewal of the carbons only has been added to the cost

of energy, leaving out of account repairs and depreciation, whereas in the case of the Osram lamp the cost of renewal of lamps referred correspondingly to the known useful life has been taken into consideration.

TABLE I.

High Candle-power Osram Lamp. A. Candle-power and Efficiency.

Signature of Lamp.	Mean Horizontal Candle-power. H.K.	Mean Spherical Candle-power H.K.○	Mean Hemispherical Candle-power H.K.		Watts per Candle-power. W/H.K.		
			Fittings for Indoor Use. I.	Fittings for Outdoor Use. II.	Lamp without Reflector. W/H.K.○	W/H.K.○ I.	W/H.K. II.
I_1	100	79	112	105	1·40	0·98	1·05
II_2	200	158	224	209	1·39	0·98	1·05
III_3	300	238	337	316	1·39	0·98	1·05
IV_4	400	316	447	414	1·39	0·98	1·06

TABLE Ia.—B. Running Costs.

Signature of Lamp.	Mean Horizontal Candle-power H K.	Running Cost per Burning Hour in Pfennigs.			Running Cost per 1,000 H.K. Hours in Pfennigs.				Cost of Energy.
		Current.	Renewal of Lamps.	Total.	Mean Horizontal.	Spherical.	Hemispherical.		
							Fittings for Indoor Use. I.	Fittings for Outdoor Use. II.	
I_1	100	4·5	0·625	5·125	51·3	64·9	45·7	48·8	45 Pf. per KW hrs.
II_2	200	9·0	1·12	10·12	50·6	64·1	45·2	48·5	
III_3	300	13·5	1·5	15·0	50·0	63·1	44·5	47·5	
IV_4	400	18·0	1·87	19·87	49·68	62·9	44·3	48·0	
						Mean	44·9	48·2	
						Mean from I. & II.	46·5		

TABLE Ib.—C. Running Costs.

I_1	100	1·0	0·625	1·625	16·25	20·6	14·5	15·5	10 Pf. per KW hrs.
II_2	200	2·0	1·12	3·12	15·62	19·8	13·9	14·9	
III_3	300	3·0	1·5	4·5	15·0	18·9	13·3	14·2	
IV_4	400	4·0	1·87	5·87	14·69	18·6	13·1	14·2	

TABLE II.

Small D.C. Open Arc Lamps with Ordinary Carbons.

A. Candle-power and Efficiency.

Signature of Lamp.	Current in Amperes.	Voltage across Arc.	Supply Voltage.	Consumption of One Lamp Watts.	Hemispherical Candle-power H.K.○	Watts per Candle-power.		
						W/H.K.○	Percentage of W/H.K. consumed by Osram Lamps of same Candle-power.	
							I.	II.
I_3	3	42 to 45	110	165	112	1·47	150	140
II_4	4	42 ,, 45	110	220	187	1·17	119	111
III_5	5	42 ,, 45	110	275	262	1·05	107	100
IV_6	6	42 ,, 45	110	330	356	0·93	95	88·5
V_7	7	42 ,, 45	110	385	457	0·84	86	80

TABLE IIA.—B. Running Costs.

Signature of Lamp.	Hemispherical Candle-power as given in Table II.	Running Costs per Burning Hour (repairs and depreciation not included).					Running Costs per 1,000 H.K.$_{\supset}$ Hours.		
		Cost of Energy. Pfennigs.	Renewal of Carbons. Pfennigs.	Cost of Attendance on Lamp. Pfennigs.	Total Pfennigs.	Cost of Energy per Unit.	Pfennigs.	Percentage of Cost of Osram Lamps on basis of same Candle-power. I.	II.
I_3	112	7·43	1·20	0·30	8·93	45 Pf. per KW Hour	79·8	174	163
II_4	187	9·90	1·30	0·30	11·50		61·5	136	127
III_5	262	12·35	1·40	0·30	14·05		53·7	120	112
IV_6	356	14·83	1·50	0·30	16·63		46·8	105	98
V_7	457	17·30	1·60	0·30	19·20		42·0	95	87

TABLE IIB.—C. Running Costs.

I_3	112	1·65	1·20	0·30	3·15	10 Pf. per KW Hour	28·1	194	181
II_4	187	2·20	1·30	0·30	3·80		20·3	146	136
III_5	262	2·75	1·40	0·30	4·45		17·0	125	116
IV_6	356	3·30	1·50	0·30	5·10		14·3	108	100
V_7	457	3·85	1·60	0·30	5·75		12·6	96	89

TABLE III.—Enclosed D.C. Arc with Clear Inner Globe and Diffusing Outer Globe.
A. Candle-power and Efficiency.

Signature of Lamp.	Current in Amperes.	Supply Voltage.	Voltage across Arc.	Consumption. Watts.	Hemispherical Candle-power. H.K.$_{\supset}$	Watts per Candle-power. In Watts H.K.$_{\supset}$	Percentage of W/H.K. consumed by Osram Lamp of same Candle-power. I.	II.
I	2·5	110	75	275	112	2·46	251	234
II	4·0	110	75	440	262	1·68	171	160
III	5·8	110	81	640	465	1·38	141	131
IV	6·5	110	80	715	517	1·38	141	131

TABLE IIIA.—B. Running Costs.

Signature of Lamp.	Hemispherical Candle-Power as given in Table III. H.K.$_{\supset}$	Running Costs per Burning Hour. Current. Pfennigs.	Renewal of Carbons and Inner Globe. Pfennigs.	Cost of Attendance on Lamp. Pfennigs.	Total. Pfennigs.	Running Costs per 1,000 H.K. Hours. In Pfennigs.	Percentage of Cost of Osram Lamp on Basis of same Candle-power. I.	II.	Cost of Energy.
$I_{2·5}$	112	12·4	0·30	0·015	12·72	114	250	234	45 Pfennigs per K.W. hour.
$II_{4·0}$	262	19·8	0·30	0·015	20·12	77	172	160	
$III_{5·8}$	465	28·8	0·30	0·015	29·12	62	139	130	
$IV_{6·5}$	517	32·2	0·30	0·015	32·52	62	140	129	

TABLE IIIB.—C. Running Costs.

$I_{2·5}$	112	2·75	0·30	0·015	3·07	27·4	189	177	10 Pfennigs per K.W. hour.
$II_{4·0}$	262	4·40	0·30	0·015	4·72	18·0	132	124	
$III_{5·8}$	465	6·40	0·30	0·015	6·72	14·5	111	102	
$IV_{6·5}$	517	7·15	0·30	0·015	7·47	14·5	110	101	

TABLE IV.

A.C. Open Arc with Ordinary Carbons and Diffusing Outer Globe.

A. Candle-power and Efficiency.

Signature of Lamp.	Current in Amperes.	Supply Voltage.	Voltage across Arc.	Number of Lamps in Series on 110 Volt.	Consumption of One Lamp. Watts.	Hemispherical Candle-power. H.K. ⊃	Watts per Candle-power. In Watts. H.K. ⊃	Percentage of Watts/H.K. consumed by Osram Lamp of same Candle-power. I.	II.
I_6	6	110	29	3	168	82·5	2·04	208	194
II_8	8	110	29	3	222	150	1·48	151	141
III_{10}	10	110	29	3	276	225	1·22	124	116
IV_{12}	12	110	30	3	340	300	1·13	115	107
V_{15}	15	110	30	3	425	405	1·05	107	100
VI_{20}	20	110	31	3	605	540	1·12	114	106

TABLE IVA.

A.C. Open Arc with Ordinary Carbons and Diffusing Outer Globe.

B. Running Costs.

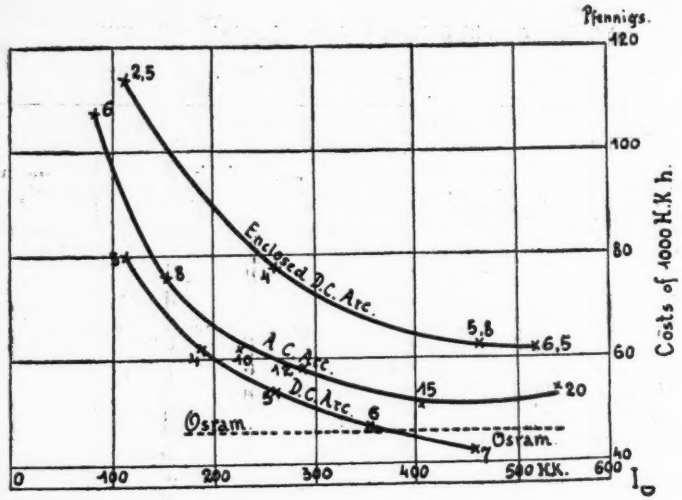
Signature of Lamp.	Hemispherical Candle-power as given in Table IV.	Running Cost per Burning Hour.* Current. Pfennigs.	Renewal of Carbons. Pfennigs.	Cost of Attendance on Lamp. Pfennigs.	Total. Pfennigs.	Running Costs per 1,000 H.K. ⊃ Hours. In Pfennigs.	Percentage of Cost of Osram Lamp on Basis of same Candle-power. I.	II.	Cost of Energy.
I_6	82·5	7·55	1·0	0·3	8·85	107	234	219	45 Pfennigs per K.W. hour.
II_8	150	10·00	1·1	0·3	11·40	76	167	156	
III_{10}	225	12·40	1·2	0·3	13·90	62	137	128	
IV_{12}	300	15·30	1·4	0·3	17·00	57	128	120	
V_{15}	405	19·10	1·5	0·3	20·90	51	115	106	
VI_{20}	540	27·20	1·6	0·3	29·10	54	122	112	

* The fact that three lamps can be run in series on 110 volts must be borne in mind.

TABLE IVB.—A.C. Arc with Ordinary Carbons.

C. Running Costs.

I_6	82·5	1·68	1·0	0·30	2·98	36·1	249	233	10 Pfennigs per K.W. hour.
II_8	150	2·22	1·1	0·30	3·62	24·1	170	159	
III_{10}	225	2·76	1·2	0·30	4·26	18·9	136	127	
IV_{12}	300	3·40	1·4	0·30	5·10	17·0	128	120	
V_{15}	405	4·25	1·5	0·30	6·05	14·9	114	105	
VI_{20}	540	6·05	1·6	0 30	7·95	14 7	112	103	



The numbers attached to the points on the curve represent the current in Amperes taken by the various arc lamps.

FIG. 5.

The Chicago Acetylene Congress.*

* Abstracted from *The Acetylene Journal*, Chicago, September, 1908.

THE Annual Congress of the International Acetylene Association was held in Chicago and opened on Monday, August 10th, of this year.

The address of the President, MR. M. J. CARNEY, was optimistic; he referred to the spread of the illuminant in the rural districts, and said that the public were now beginning to get accustomed to the use of acetylene, and to lose that suspicion as its to reliability and safety that had been recognized to exist earlier in its career. Some stress was, however, laid by several speakers on the need for good workmanship and the injury done to the industry by the issue of imperfect apparatus and the sacrifice of reliability to cheapness.

MR. KIRCHBERGER, in his paper on the **'Ethics of Selling Goods,'** wisely deprecated the putting forward of claims of an exaggerated nature, which the non-technical consumer was obviously unable to refute, but which in the long run were proved to be incorrect, and recoiled upon the salesman.

MR. C. UMRACH, speaking from the standpoint of the manufacturer of acetylene fixtures, also spoke of the tendency to sell goods cheap at all costs, and insisted that it was more essential that the generators, &c., sold should be properly tested previously, and guaranteed to be perfect in construction.

These points, particularly vital to users of acetylene, were dealt with by MR. MERRILL from the standpoint of insurance companies, who had originally viewed acetylene very dubiously indeed.

The influence of the stringent insurance rules on the industry is now understood to have been beneficial. According to the report of the Insurance Committee of the Association, however, the National Board of Fire Underwriters have now decided to relax the existing regulations in several particulars, especially as regards permission to install acetylene generators

indoors, and to store carbide in bulk up to 100-pound drums, instead of in the form of two-pound cans as was formerly prescribed.

Among the papers read at the Convention we note that of MR. W. J. STINSON, who contended that, both as regards initial cost and upkeep, acetylene had the advantage over other systems of town illumination, and had been largely employed in small towns.

Some discussion also centred round a paper by MR. J. M. BROCK on **'Burner Troubles and their Remedy.'** The majority of those present appear to have put forward the view that little or no trouble of this kind was experienced in the case of up-to-date burners. MR. CARROL stated that he had never experienced any trouble after the gas had been allowed to pass through a filter of wool or felt on its way to the burner.

The question of pressure was also discussed, and it appeared to be agreed that the best pressure was in the neighbourhood of about three inches of water; it was moved that a committee be appointed to consider the advisability of modifying the existing pressure of 2½ inches, as at present prescribed by the Society.

MR. A. F. JENKINS spoke of the value of acetylene for outdoor illumination and its advantage over petrol air and gasoline plants under wet and stormy conditions.

MR. A. CRESSY MORRISON read a paper advocating the **Use of the Acetylene Light by Medical Men,** on account of the presumed resemblance of its spectrum to daylight. The accentuation of one or another colour, he suggested, tended to prejudice the physician's judgment, and the simplicity and portable nature of many acetylene lights were also advantageous.

MR. O. F. OSTBY spoke of the **Future of Dissolved Acetylene,** and its value for head-lights and in light-houses, and MR. NORDVALL, of Stockholm, gave some figures as to the cost of the coast beacons in Sweden. In that country, he said, there were about twelve to fifteen hundred small beacons in use, and the introduction of acetylene, he claimed, had saved the Government about 300 dollars a year for each beacon, thus making in all a very considerable amount. Hence the Government had now decided to entirely supersede oil by acetylene, and the same course was being followed in Norway, Denmark, Finland, Russia, Ireland, Italy, Spain, and Germany.

The application of dissolved acetylene, in accordance with the scheme of MR. DALEN, chief engineer to the Gas Accumulator Co., Ltd., of Stockholm, enables lights on buoys, light ships, &c., to be turned on and off automatically at given intervals, with the result that they can now be left to themselves for long periods of time, without any personal supervision whatever. This, it is claimed, reduces the running costs very materially, but without unduly increasing the initial expense. By the aid of a special valve Mr. Dalen automatically extinguishes lights at dawn and relights them at dusk; it is interesting to observe that in addition his system permits 'the production of flashes at suitable intervals, by the actual extinguishing, instead of merely the obstruction of the light. In the case of lights that are being constantly flashed at regular intervals all through the night, this, of course, represents a very considerable saving. Another means of saving consists in the use of a special pilot flame which consumes only 10 litres (*i.e.*, about 0.4 cubic feet) in twenty-four hours, as contrasted with the pilot flames used in connexion with generating systems, which consume 3 cubic feet of gas in the same time, and in addition are usually in duplicate or triplicate.

The "sun valve," by the aid of which the automatic extinction and lighting of buoys, &c., is accomplished, appears to depend upon the action of the increase in temperature of a body, having an absorbing surface, when exposed to solar radiation. The increase in temperature so caused, and the subsequent expansion operates a valve opening and closing the gas inlet. It is claimed that on the average a saving of 30 to 40 per cent of the gas generated is accomplished in this way.

Some of the papers read before the Congress, which it will be seen cover a wide ground, and to which more detailed reference may subsequently be made, are as follows:—

Town-Lighting by Acetylene, by W. J. Stimson.
The Manufacturing of Acetylene Fixtures, by C. Ummach.
Frost-proof Generator Houses, by P. A. Rose.
Personal Experiences with Artificial Illuminants, by H. E. Shaffer.
Burner-troubles, the Cause and the Remedy, by J. M. Brock.
The Ethics of Selling Goods, by M. Kirchberger.
Some Industrial Uses and Possibilities of Acetylene, by A. F. Jenkins.
The History and Present Status of the Oxy-Acetylene Process in America, by A. Davis.
Acetylene in New Fields, by Prof. G. G. Pond.
The Freezing of Acetylene Generators and How to Obviate, by A. T. Mertes.
Medical Diagnosis under Artificial Light, by A. Cressy Morison.
The Value of Co-operation with the Insurance Underwriters, by W. H. Merril.
The Present and Future of Dissolved Acetylene, by O. O. Ostby.

Conclusive Evidence of the "Overshooting" of Tungsten Lamps.

By J. S. Freeman.

[(*Electrical World*, N.Y., Aug. 15th.)

The author refers to the interesting fact, which has recently received attention from J. B. Taylor (*Elec. World*, N.Y., May 23rd), that the light from a tungsten lamp, unlike ordinary carbon filament lamps, appears to flash up to an abnormal brilliancy for a very short interval of time after the lamp is switched on; this, however, does not seem to occur when the lamp is switched off and then again lighted while still in a hot state.



Fig. 1.—Overshooting of Cold Tungsten Lamp.

Mr. Freeman investigates the question by the aid of the oscillograph. During the investigations a 22-volt tungsten lamp was placed within an enclosed tube in the oscillograph box so that the light could shine through a small aperture on to the revolving film. Arrangements were then made to secure simultaneously a record of the current and the spot of light from the lamp, upon the oscillograph film.

In this way the result shown in Fig. 1 was obtained. The intensity of the light, as exhibited by the whiteness of the band at the top of the figure, rises beyond



Fig. 2.—Warm Tungsten Lamp.

its subsequent value for a short time after the lamp is turned on. The current likewise attains a high initial value, jumping from A to B, and subsequently gradually dies away to its normal value from C to D, where the lamp is switched off.

From Fig. 1 the author draws the conclusion that the total excess of brilliancy lasts for about one-fifth of a second, and the period of greater brightness is about one-tenth. The filament arrives at incandescence in the short time of about one-sixtieth of a second only, and retains its high temperature for about one-thirtieth of a second after the current is turned off.

Fig. 2 shows conditions similar to those exemplified in Fig. 1, but on account of the initial warm state of the lamp the "overshooting" does not appear. The author mentions that the apparent

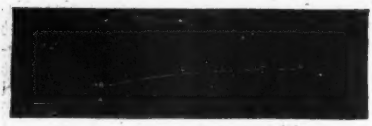


Fig. 3.—Action of Carbon Lamp.

greater rise in current is merely due to the oscillating mirror being set differently so as to reproduce the current-curve on a larger scale.

Fig. 3 represents the entirely distinct conditions occurring in the case of the carbon lamp. In this case the current *rises* gradually from its initial value of 0·15 amps. at B to its final value of 0·3 amps. (C to D). About one-fifth of a second was required for the conditions to become normal.

In Fig. 4 is shown an interesting record of the fluctuations in the light of a 25-volt tungsten lamp, taking place syn-



Fig. 4.—Behaviour of Tungsten Lamp at 25 cycles.

chronously with the pulsations of a 25-cycle alternating current. On closing the circuit there were 3·4 effective amperes, but under normal conditions only 0·3 amperes passing through the lamp.

The filament, it will be noticed, begins to brighten at the maximum point of the wave and itself reaches a maximum about one-eighth of a cycle further on; similarly the minimum brightness is not at zero.

CORRESPONDENCE.

The Temperature of the Sun.

Redaktion der Zeitschrift 'The Illuminating Engineer.'

In No. 8 (August) Ihrer gesch. Zeitschrift finde ich eine Bemerkung, welche sich mit dem Inhalt meines Vortrages: 'Ueber die Temperatur mit welcher Glühlampen strahlen' beschäftigt. Herr Wanterno hält mir entgegen, dass ich den Wert für die Sonnentemperatur zu klein gefunden habe, weil ich die Absorbtion in der Atmosphäre der Erde nicht genügend berücksichtigt hatte. Zunächst handelt es sich in meiner Untersuchung keineswegs darum die Sonnentemperatur zu finden. Ich wollte bloss durch ein Beispiel zeigen, wie das Wien'sche Gesetz zur Ermittlung hoher Temperaturen anzuwenden ist. Andrerseits muss ich aber bestreiten, dass die gefundene Temperatur von den neuesten diesbezüglichen Untersuchungen erheblich abweicht, vielmehr geben alle ernst zu nehmenden Untersuchungen aus der neuesten Zeit im Mittel ungefähr die von 6,000 Grad als den wahrscheinlichen Wert der mittleren Temperatur der Chromosphäre der Sonne an.

Bedenken wegen der Absorbtion der Medien, welche zwischen dem strahlenden Körper und dem Bolometer liegen, sind gewiss gerechtfertigt, aber die Absorbtion in der Erdatmosphäre ist noch lange nicht so ausschlaggebend fur die Diskussion des gewonnenen Resultates, wie die selektive Absorbtion in den einzelnen Teilen des Spektrographen selbst. Ausserdem ist der von mir angenommene Wert von λ max. in Bezug auf die Strahlung der Sonne derjenige, welchen z. B. Dr. Scheiner als ausserhalb der Atmosphäre geltend angibt.

Mir war das Alles sehr wohl bekannt und ich habe es deshalb vermieden einen präzisen Wert für die Temperatur der untersuchten Lampen anzugeben.

Für die Veröffentlichung dieser Zeilen bestens dankend zeichne ich

hochachtungsvoll

KARL SARTORI.

Wien, 29 August, 1908.

To the Editor of 'The Illuminating Engineer.'

SIR,—In the August number of your valued journal I observe several remarks bearing on the contents of my paper on 'The Temperature of Incandescence of Glow-Lamps.' Mr. Wanterno contends that I have estimated the temperature of the sun at too low a value through not having sufficiently taken into consideration the absorption of the earth's atmosphere.

I may remark that my paper contains no attempt to determine the temperature of the sun, and that I merely wished to show, by way of example, how the Law of Wien can be applied to estimate high temperatures. Moreover, I must point out that it is not correct to assume that the temperatures determined, as a result of the most recent investigations on this subject, are very different from this value. On the contrary, all the most recent and reliable investigations yield a mean value for the probable temperature of the solar chromosphere in the neighbourhood of 6,000°.

Consideration of the absorption of the medium, lying between the radiating body and the bolometer is certainly justified, but the absorption due to the earth's atmosphere is less material in the discussion of results obtained than the selective absorption in different portions of the spectrometer itself. Apart from this the value for λ max. quoted by me for the maximum of the energy-curve of solar radiation, is that deduced by Dr. Scheiner for radiation as occurring *outside* the atmosphere.

All this was quite familiar to me, and I therefore abstained from giving any exact value for the temperature of incandescence of the glow-lamps examined.

Thanking you for the publication of these remarks, I remain,

Yours truly,

KARL SARTORI.

Vienna, Aug. 29, 1908.

The Absorption of Arc-Lamp Globes.

Laboratories of Applied Electricity,
The University, Liverpool.

September 21st, 1908.

DEAR SIR,—I have read with great interest the article by Prof. J. T. Morris on 'Tests on Recent Flame Lamps.' There are many interesting points in his paper, but I should like to refer to the figures he gives for the absorption of globes.

I have obtained no results approaching most of his figures for absorption, when testing an arc-lamp. The only result which tends to approximate to them was with an open arc with a large opaline globe, in which the apparent absorption, as measured by determining the mean hemispherical candle-power, was 68 per cent. This figure agrees fairly closely with the 57 per cent given by M. Blondel in some tests on open arcs under similar conditions.

Much as I should like to believe that the results of Prof. Morris for the light emitted by an arc as given in his Table III. are to be accepted, I cannot think they are correct. If the light emitted by an arc-lamp has to be found, surely the most direct way of finding it is to measure it. It does not seem justifiable to measure the light given by a naked lamp and then to assume that if a globe, the absorption of which has been measured with a different kind of light and under dissimilar conditions, is placed round the arc, the light given out will be reduced by the same fraction as in the absorption test.

It is, of course, possible that the enclosure of the arc may alter its character to such an extent that what appears to be absorption may really be actual reduction in light given by the arc itself. A very simple observation will show that this is not a complete explanation of the very large absorption which undoubtedly occurs. If an ordinary arc is enclosed in a globe with a hole in it, the patch of light corresponding to the hole is many times brighter than the surrounding surface, and although I have not made any measurements, I think that such measurements would indicate an absorption much more nearly 80 than 20 per cent.

As to the reasons for this great apparent absorption as compared with the figures obtained by Prof. Morris by measurements with an incandescent lamp, I think there are several. The arc light is a naked light, and does not come from a filament enclosed in a glass bulb, and the selective absorption of the glass would not be greatly increased by the addition of another globe. The absorption of a clear glass globe may reach 30 per cent, and I have a test result given by Prof. Ayrton, in which an apparently clear globe absorbed 47 per cent. Further, the fumes from a flame arc must make an atmosphere inside the globe which is more or less opaque; then, again, there are contrivances, such as ash trays, &c., which altogether block the light sometimes in the direction of maximum effect. Some of these sources of loss it is, of course, almost impossible to eliminate, but I feel certain that a more careful design of the globe, possibly a more careful choice of glass for the globe, would lead to a large increase in the working efficiency of the flame lamp.

The curves given by Prof. Morris in his paper are, I think, curves without globes in the case of the open flame lamps.

I should like, in conclusion, to express my great appreciation of the valuable work Prof. Morris has done in testing these lamps.

Yours very truly,

E. W. MARCHANT.

To the Editor of 'The Illuminating Engineer.'

DEAR SIR,—I desire to express my thanks to Dr. Marchant for his appreciation and for his kind criticism of my recent article in your journal on 'Flame-Arcs.' In reply I must own that I was not entirely satisfied with the tests of absorption of the globes, and hence marked them as approximate only.

In view, however, of the great divergence between Dr. Marchant's results and my own, I am endeavouring to put the matter to a crucial test, and shall hope to send you the results for your kind inclusion in your next issue. But I would draw attention to the fact that *all* the tests recorded were made, as stated, with the globes on, and therefore under working conditions, consequently an error in the correction for absorption does not affect the practical results, but only the corrected mean spherical candle-power. This latter is, nevertheless, a most important scientific quantity.

I entirely agree with Dr. Marchant that greater care should be exercised in the design of globes and in the choice of the kind of glass used.

I am, yours sincerely,
J. T. MORRIS.

The Effect of Ultra-Violet Light on the Eyes.

DEAR SIR,—I have followed with interest the discussion that has been taking place on this subject; but there appear to me to be two points, on which general conclusions may be formed, that deserve special attention.

In the first case I should like to point out that, although photographic experiments, spectrophotographs, &c., may be useful in order to furnish a qualitative examination of the sources of light, it is at least open to question whether any *quantitative* estimations of physiological effect can be based on such a method. Some of Voege's experiments, for instance, seem to me merely to show that, for a given intensity of illumination, daylight is richer in photographically active rays than almost all artificial illuminants. But it does not follow that these are the particular rays that are physiologically undesirable, and it seems conceivable that rays in the spectrum may exist which have but little effect on a photographic plate, and yet give rise to marked physiological effects.

Secondly, I think one must be cautious in drawing conclusions too readily from so-called "natural phenomena." Occasionally people ridicule the idea that artificial illuminants ought to be screened down to a low intrinsic brilliancy, on the ground that the sun itself is far brighter than them.

Yes. But we are not obliged to look straight at the sun, and, indeed, would suffer severely if we habitually did so; on the other hand, it is often extremely difficult so to place artificial sources of light that we do not look straight at them occasionally, and therefore it is more important to protect our eyes in this case.

The same holds good about ultra-violet rays. Even supposing daylight is richer in these rays than artificial light, probably our methods of using the latter may lead us to expose our eyes much more severely.

I am, yours faithfully,
ATHOS.

Trade Notes, Catalogues Received, &c.

Ships' Searchlights.

Messrs. Siemens Bros. send us some particulars of their latest types of searchlight-projectors. Searchliggts are now regarded as part of the equipment of all types of vessels. On warships they are essential for the purpose of locating the enemy by night and for signalling, and in the merchant service they are of use in the navigation of difficult waters and for picking up buoys,



&c. An example of one of the types of projectors of the above firm is shown in the accompanying illustration.

Projectors can be supplied with or without electrical control of the training and elevating motions, and all the usual special attachments, and with diameters of 10, 12, 14, 16, 20, and 24 inches. In the merchant service the 12 in. and 16 in. sizes are most usual.

We have received a notice of *Electrical Engineering*, by Mr. H. A. Simmons, A.M.I.E.E., which is to be issued by *Messrs. Cassell & Co.* in fourteen fortnightly parts, commencing from September 24th of this year.

The B.T.H. Meridian Lamp.

We have received from the British Thomson-Houston Co. a catalogue giving particulars of the B.T.H. Meridian Lamp and the various fixtures intended for use with it.

The lamp is at present made in only one size, giving approximately 55 candle-power, and consuming 120 watts. Lamps are made for voltages from 100-125 and 200-250.

Messrs. *The Union Electric Company, Ltd.*, send us a variety of lists, Nos. 1403, 1404, 1405, dealing with guide attachments and cradles and hoisting gear for arc lamps, resistances for arc lamp circuits. Another list deals with a newly developed contact-voltmeter, relays, signal bells and lamps, &c.

Messrs. *The Robertson Electric Lamp Co.* send us some particulars of their exhibit at the forthcoming Manchester Electrical Exhibition, which is to be on the same lines as that at Olympia, and to include actual demonstrations of glow-lamp monufacture.

We have received a pamphlet issued by *Messrs. Seren & Co., of Vienna*, relating to a new method of acetylene generation by the aid of specially prepared "briquettes," which are claimed to enable the evolution of acetylene from the carbide to take place under very favourable conditions.

The generators are made in two sizes, intended for use in an ordinary dwelling-room or for supplying an entire house, and capable of giving gas to three open-flame burners for about seventeen hours or six open-flame burners for seventeen hours respectively.

We have also to acknowledge a list of the hanging fixtures for carbon and metallic filament lamps, sent us by the *Siemens-Schukert-Werke*, of Vienna; some particulars of the *Jandus Regenerative Flame Arc*; and a list of decorative fixtures from *Messrs. Waring & Gillow.*

A Course in Illumination.

We have received a copy of the prospectus of the Northampton Institute for the forthcoming year, and were interested in the account of the course conducted by Dr. C. V. Drysdale on 'The Production and Utilization of Light,' in which the scientific principles underlying the manufacture of light for illuminating purposes receive detailed attention.

The lectures referred to are supplemented by a course on 'The Chemistry of Incandescent Lighting,' and laboratory work on photometry.

It is gratifying to find that in this instance, at least, the study of illumination occupies a definite place in the college curricula, and there are indications that the subject of illumination is about to receive attention on similar lines in other quarters.

Review of the Technical Press.

Photometry.

The most interesting item among the photometric papers of the past month is the communication of **Dr. Glazebrook** to the British Association meeting regarding the Standard at the National Physical Laboratory.

Hitherto it has been specified that the standard conditions of moisture should be taken as 10 litres of water-vapour per cubic metre of air, measured with an ordinary unventilated wet and dry bulb hygrometer. It now appears that, on the Assmann instrument, which is used on the Continent, the 10 litres referred to would be registered as 8. In future the laboratory propose to adopt the Assmann instrument, but to keep the value of the light-standard the same; all that is necessary is to adopt the new method of specifying the water-vapour.

A most interesting result of this discovery is that the corrected values of the relations connecting the British candle-power with the Hefner and Bougie decimale become simplified to the convenient whole numbers 0·9 and 1·0 respectively. It is also stated that the adoption of the new method of specifying the water-vapour will, to a great extent, explain the old want of agreement between the results of direct comparison between the standard lamps, and the results of comparison by the aid of glowlamps interchanged between the various laboratories; a small difference of somewhat over 1 per cent. will, however, still remain unaccounted for, and this is still the subject of investigation.

In view of the alteration in the relation between the units of different countries, the recent proposition of the National French Committee of the International Electrotechnical Commission to bring the British, French, and American standards into closer agreement, by raising the British candle 2 per cent, and lowering the United States candle 2 per cent (see *Electrical World*, N.Y., September 5th), will have to be reconsidered.

Among other articles dealing with the subject of photometry mention may be made of the translation of the recent publication of **Kruss** on Integrating Photometers, which appears in the American *Gaslight Journal*.

There are also short notes on several new forms of photometers. Thus the *Elektrischer Anzeiger* (Sept. 10th) describes A New Form of Portable Photometer due to **Blondel**. The instrument utilizes a diminutive Lummer-Brodhun prism arrangement, of a special pattern, forming a "contrast" field, which is afterwards highly magnified. The alteration in brightness of the field of view is accomplished by means of an arrangement of screens, and the whole is specially designed so as to be of a portable nature, and easily adapted to measurements in the street, &c. For the purpose of measuring illumination, a small glow-lamp, with a linear filament, fed from a portable accumulator, is employed.

We also note in the *Journal für Gasbeleuchtung* (Sept. 19th, p. 891) a short note of A New Flicker Photometer devised in Russia. Little detail is given, but the essential point of the instrument seems to lie in a device to secure that the alteration in brightness of the field of view takes place according to a sinusoidal law. The object of this is to avoid the sudden changes of light and shade occurring in the ordinary flicker-photometer, which are said to be fatiguing to the eyes. It might naturally be supposed, however, that it is in this very sharpness that the sensitiveness of such an instrument exists, and that any attempt to render the flicker more "restful" in this way could only impair the sensitiveness.

Illumination.

As usual a considerable number of papers dealing with broad aspects of illumination have appeared in the American press. **Marshall** (*Electrical World*, Sept. 12th) advocates the Inspection of the Illumination of Premises by supply companies, as well as the examination of wiring. He hardly supposes that the company should go so far as to refuse to supply current to an inadequately arranged system of lighting as would be done in the event of the wiring being unsatisfactory; but he thinks that a friendly inspection of installations previous to connecting up might often enable the engineer to make a few suggestions which would save much subsequent friction. He also refers to the value to a central station of a complete illuminating engineering staff for the special purpose of advising and assisting consumers.

In another article the same author discusses the functions of The Illuminating Engineer. As not infrequently occurs in such discussions the author eventually comes round to the

relation of the illuminating engineer to the architect on the goodwill of whom much of the success or otherwise of his efforts must depend. Mr. Marshall has no doubt of the illuminating engineer's ability to assist in this way, and even states that he has never met a case in which an architect has called in the assistance of an independent illuminating expert without gaining benefit thereby.

On the other hand **Mr. Basset Jones**, speaking from THE ARCHITECT'S STANDPOINT (*Elec. Review*, N.Y., Sept. 12th), seems to consider that some illuminating engineers are apt to make unreasonable demands. For instance, it is hardly fair to expect the architect to subjugate his scheme to the wishes of the engineer in order that the latter may gain the maximum efficiency from his lights. Efficiency is rarely the only consideration. Arguing by analogy, Mr. Basset Jones points out that no sanitary engineer would expect the architect to design the house to suit his views, or object because he adopted some system which deprived the hot-water apparatus of some fraction of its possible efficiency. Mr. Basset Jones likewise deprecates the incursions of the illuminating engineer into the department of the æsthetic pure and simple, and hints that in many cases he has not as yet received the education to enable him to appreciate what is good art and what is not.

The Illuminating Engineer of New York, as usual, contains a number of articles dealing specifically with illumination. Amongst these we note an article by **N. McBeth** on THE ILLUMINATION OF A CLOTHING STORE, and a well-illustrated article dealing with SPECTACULAR EFFECTS IN INDOOR-LIGHTING, showing some novel imitative method of decoration. A recent paper by **A. Cressy Morison** discusses the best light from the point of view of DIAGNOSIS BY THE MEDICAL MAN. Naturally in examining the conditions of the skin, and noting symptons of inflammation &c., a light approaching to daylight is desirable, otherwise certain colours may be inconveniently accentuated, and thus give rise to deceptive effects. For instance, a preponderance of red in the spectrum of an illuminant is apt to cause an appearance of inflammation when none really exists. Mr. Morison recommends acetylene, on account of the presumed resemblance of its spectrum to that of daylight.

K. Norden (*E.T.Z.*, Sept. 10th) considers some theoretical points arising in the derivation of ILLUMINATION FROM THE MERCURY VAPOUR LAMP. As the mercury lamp is far from a point-source light, being a tube of very considerable dimensions, the ordinary inverse-square law does not apply to the lamp as a whole, and the calculation of the resulting illumination at any point presents some complications.

The author shows how to calculate the illumination at any such point in a plane parallel to the axis of the tube. He also deals with the errors that are liable to be introduced in the photometry of this source owing to its deviation from the theoretical point-source, some of which are very marked. For instance, it was found that when the distance of the lamps from the photometer was varied from 0·6 to 2·85 metres, a difference in the apparent candle-power of as much as 34 per cent occurred.

The *Zeitschrift für Beleuchtungswesen* reproduces an article by **E. W. Weinbeer** who works out the SHAPE OF REFLECTORS in order to secure a UNIFORM GROUND ILLUMINATION. A recent number of the *Journal of Gaslighting* abstracts the paper by **Nichols** before THE ILLUMINATING ENGINEERING SOCIETY on 'DAYLIGHT AND ARTIFICIAL ILLUMINATION.'

A very interesting discussion has raged round the paper by **Schanz** and **Stockhausen** at the VERBAND DEUTSCHER ELEKTROTECHNIKER on the EFFECTS OF ULTRA-VIOLET LIGHT ON THE EYE. Many conflicting views were expressed. The most general view, however, seems to have been that, since daylight contained a stronger ultra-violet element than ordinary artificial illuminants, the injury due to the latter could not justly be ascribed to the effects of ultra-violet light. On the other hand, injury might, of course, be due to other causes, too severe contrast, too great intrinsic brilliancy of visible rays, &c. In the case of such sources as the quartz mercury-vapour lamp, protection from the ultra-violet light is, however, recognized to be necessary.

It was also pointed out that much additional work in this subject must be necessary before it could be said to be ripe for discussion, and some speakers deprecated the publication of hasty conclusions which were afterwards taken up by the press, and gave rise to an anxiety in the minds of the public for which there was no reasonable ground. Others, however, expressed the view that since suggestions of this nature had been made from time to time, it was most desirable in the interests of the electrical industry that the matter should be debated and some idea formed as to how far such fears were justified.

In the last number of the *E.T.Z.* **Prof. Blondel** contributes a letter describing

some of his experiences. He agrees with the suggestions of Schanz and Stockhausen, that the fatigue of the eye is due to ultra-violet, or rays of short wavelength, and thinks that this may possibly be explained on the ground that, though daylight contains more energy of this description than most artificial lights, yet, owing to the relatively low standard of intensity prevailing with artificial illumination, our vision is mainly accomplished by the aid of the "rods" in the eye, which is not the case in bright daylight, so that the physiological conditions are altered. He himself suffered from inflammation of the conjunctiva, and found subsequently that while his eyes could bear a lamp taking 4 or 3·5 watts per candle, a lamp taking 2·5 watts per candle, and therefore giving a whiter light, gave rise to eye-trouble. Even the use of low efficiency lamps, however, was only possible after the inflammatory symtoms had subsided to some extent, and the author was at first unable to work by artificial light with comfort.

Electric Lighting.

The number of articles published within the last month dealing with electric lighting is more extensive than ever. Particular attention may be drawn to the two "Special Illumination Numbers" of *The Electrical World* and *The Electrical Review* of New York of September 5th and 12th respectively. In these and other American journals appear a vast number of papers by **A. A. Wohlauer S. E. Doane, F. W. Wilcox, L. P. Sawyer,** and others dealing with the Progress and Development of the Tungsten Lamp. Most of these deal with the subject in a general manner, as is natural in an issue of this nature, reviewing the most recent developments and giving tables of comparison between the costs of lighting by the tungsten lamps and gas; there are also some collected opinions of supply companies in different parts of America on the effect of the introduction of the lamps on business. These are almost invariably favourable, and there do not seem to be any signs of the uncertainty as to the influence of the lamps on the revenue of supply companies observable in this country. Actual experience of the behaviour of the lamps seems to be equally favourable: thus F. W. Wilcox attributes an average life of 2,000 hours without appreciable blackening, to osram street lamps at 1·25 watts per candle.

Dr. Louis Bell reviews the progress of the tungsten lamp abroad; **A. A. Wohlauer** and **F. W. Willcox** review the Present State and Future Prospects of the Flame Arc.

Among other articles in these special numbers we note some particulars on the Helion Lamp by **H. C. Parker** and **W. G. Clarke**. It is stated that there is now no difficulty in making lamps for either 110 or 220 volts. Originally filaments were found to be very sensitive to the effects of gases occluded in the cement used to mount the leading in wires into the glass; it was found difficult to exhaust the lamps sufficiently well to prevent the filaments deteriorating subsequently. More recently, however, the authors seem to have succeeded in producing filaments that are even capable of burning in the open air, and it is stated that a filament burned at a temperature of about 1800 degrees under these conditions does not suffer appreciably thereby. Even when the temperature is carried up to 2500 degrees, with the result that silicon dioxide is formed in a molten condition, the filament is said to be uninjured. Filaments can also be immersed in water and withdrawn without being injured. During the initial period of the life of a lamp there is a slow rise in candle-power owing to the gradual burning away of the material in the carbon core on which the outer "helion" skin is formed.

D. McF. Moore likewise publishes some partciulars of the Tube-light, as Applied to the Colour-Matching Department in some printing-mills. It is stated that for this purpose the lamp is even preferable to daylight, for daylight itself gives distinctly different results at different times in the day, while the Moore lamp is always the same. A tubular reflector is now fitted upon the lamp in cases in which it is desired to concentrate the light downwards, and conditions of illumination are claimed equivalent to 0·25 watts per square foot illuminated by one candle.

Among the articles and papers that have appeared in other countries mention may be made of that by **Remane**, which is now published in full in the *Elektrotechnische Zeitschrift*. The author discusses the Effect of Overrunning on the Metallic Filament Lamps and gives a series of very interesting data as to the exact effect of a given rise of P.D. upon the life and "output" of an osram lamp taking 1·1 watts per H.K. For instance, he finds that the useful life of a 100 volt lamp run on P.D.'s of 100, 105, and 110 volts is 1,800, 900, and 370 hours respectively, so that a rise in P.D. of 10 per cent reduces the useful life to about a fifth of its normal value.

GAS, OIL, AND ACETYLENE LIGHTING.

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Gebault. Eclairage des Vitrines (*Rev. des Eclairages*. Sept. 15).
Körting, E. Public Lighting by Pressure Gas (*J. f. G.*, Sept 12, pp. 812 to 814).
Talbot, F. A. Liquid Gas (*The World's Work*, Sept. 12).
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Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

17,509. Arc-lamp (C.S.). Aug. 20. Regina Bogenlampenfabrik G. m. b. H. and P. Hanisch, 322, High Holborn, London.
17,527. Magnetic blow-outs for lamps. Aug. 20. A. Zöller, 18, Southampton Buildings, London.
17,562. Combined terminal and cord-grip for lamp holders. Aug. 21. E. Phillips, 109, Westminster Road, Hansworth, Birmingham.
17,626. Electric light fitting. Aug. 22. G. W. de Tunzelmann, 4, Queen Anne's Chambers, Westminster.
17,706. Adaptable instantaneous carrier for shades for incandescent lamps. Aug. 24. W. A. G. Hill, 116, Waterloo Street, Oldham.
17,742. Holders (glass, porcelain, &c.) for metallic filaments (C.S.). Aug. 24. I.C. April 21, 1908, Germany. Lichtwerke G. m. b. H., 18, Southampton Buildings, London.
17,787. Electroliers. Aug. 25. H. Collett and E. J. Perry, Carlton Buildings, Paradise Street, Birmingham.
17,806. Plunger connection for wiring bayonet-joint lamps. Aug. 25. E. A. Bresman, 71A, Pershore Street, Birmingham.
18,233. New system of fitting incandescent lamps (C.S.). Aug. 31. I.C. Jan. 10, 1908, France. G. Weissmann, 20, High Holborn, London.
18,278. Incandescent lamps (C.S.). Aug. 31. J. Kremenezky, 18, Southampton Buildings, London.
18,342. Glow-lamps. Sept. 1. G. Davis, Queen Anne's Chambers, Westminster. (Addition to 29,620/06).
18,408. Suspending electric lights adjustably. Sept. 2. G. Thomson, 122, George Street, Edinburgh.
18,832. Arc lamps (C.S.). Sept. 8. H. Liske and A. Zöller, 18, Southampton Buildings, London.
18,900. Lamp holders. Sept. 9. A. Bates, 24, Temple Row, Birmingham.
18,946. Metal filaments (wolfram, molybdenum, uranium, tantalum, &c.). Sept. 9. W. Heinrich, 18, Southampton Buildings, London.
19,052. Supports for lamp filaments (C.S.). Sept. 10. F. R. Pope and M. W. O'Connell, 322, High Holborn, London.
19,118. Oxide-coated metal holders for metallic filament lamps (C.S.). Sept. 11. T. McKenna, 31, Basinghall Street, London. (From Glühlampenwerk Anker, G. m. b. H., Germany.)
19,150. Fittings. Sept. 11. A. T. Woodhall and A. Emery, 70, Chancery Lane, London.

II.—GAS LIGHTING.

17,316. By-pass nipples for gas-burners. Aug. 18. B. Bonniksen and H. Fletcher, 18, Hertford Street, Coventry.
17,321. Lighting incandescent street lamps, &c. Aug. 18. T. L. Cuttell and The Anti-Vibration Incandescent Lighting Co., Ltd., 33, Chancery Lane, London.
17,596. Incandescing bodies (C.S.). Aug. 21. M. von Unruh, 47, Lincoln's Inn Fields, London.
17,617. Incandescent bodies or burners. Aug. 21. E. A. Turner, 38, Chancery Lane, London.
17,675. Reflector for inverted gas light (C.S.). Aug. 22. E. Hindrichs, 345, St. John's Street, London.
17,818. Mantles of rare earths for lighting and heating. Aug. 25. W. G. Potter, 14, Ingleton Street, Brixton Road, London.
18,093. Inverted burners for gas, &c. Aug. 28. W. G. Potter, 14, Ingleton Street, Brixton Road, London.
18,094. Lamps for burning carburetted air for lighting, &c. Aug. 28. W. G. Potter, 14, Ingleton Street, Brixton Road, London.
18,248. Inverted burners for street lighting (C.S.). Aug. 31. C. C. Carpenter, 6, Bream's Buildings, Chancery Lane, London.
18,860. Gas lighting and extinguishing apparatus. Sept. 8. Sir E. H. Elton and R. Stephens, 27, Chancery Lane, London. (Addition to 15,067/06.)
18,887. } Incandescent burners. Sept. 9. G. Helps, Izons Croft, Ansley, Atherstone.
18,901. }
18,949. Inverted incandescent burner. Sept. 9. D. Anderson and J. Worsfold, 18, Farringdon Road, London.
19,094. Burner. Sept. 11. G. Helps, Izons Croft, Ansley, Atherstone.
19,228. Incandescent burners. Sept. 12. T. E. Price, 18, Southampton Buildings, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

17,256. Petroleum incandescent lamps (C.S.). Aug. 17. O. Gronbladh, 36, Chancery Lane, London.
17,302. Lamp brackets. Aug. 18. R. W. Griffiths, 102, Bradford Street, Birmingham.
17,382. Lamps. Aug. 18. J. T. M. Burgess, Prudential Buildings, Corporation Street, Birmingham.
17,540. Light-controlled lighting switch (C.S.). Aug. 21. Sir H. Norman and T. B. Reader, Honeyhanger, Haslemere, Surrey.

17,733. Improvement on candles, paraffine, spirit or other lamps for better light. Aug. 24. A. Krakow, 57, Clifton Street, Finsbury Square, London.
17,853. Oil lamps. Aug. 25. J. C. Angus, Birkbeek Bank Chambers, London.
17,881. Reflectors for search lights, &c. Aug. 25. C. A. Parsons, G. G. Stoney and E. Bennett, 18, Southampton Buildings, London. (Addition to 16,599/07.)
18,163. Luminous sign or advertising device. Aug. 29. C. Wilson and C. Beaven, Brook Green Works, Hammersmith.
18,172. Controlling lighting or extinguishing of gas, or actuation of electric switches at predetermined times (C.S.). Aug. 29. H. W. Harris, 55, Chancery Lane, London.
18,508. Illuminating interiors without producing shadows (C.S.). Sept. 3. F. Lutthlen, 65, Chancery Lane, London.
19,096. Billiard light pendant. Sept. 11. F. Kissel, Salisbury Hotel, Boscombe.
19,183. Electroliers and gasoliers. Sept. 12. R. S. Woods, 4, St. Ann's Square, Manchester.
19,188. Mantles (gas and electric). Sept. 12. W. G. Potter, 14, Ingleton Street, Brixton, London.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

14,059. Lighting and heating of vehicles (C.S.). I.C. July 6, 1906, Germany. Accepted Aug. 26, 1908. H. Grob, 37, Essex Street, Strand.
18,688. Incandescent lamps. Aug. 19, 1907. Accepted Aug. 19, 1908. T. W. Lowden, Westinghouse Building, Norfolk Street, Strand.
19,562. Incandescent lamps (C.S.). I.C. April 15, 1907, Germany. Accepted Sept. 2, 1908. Deutsche Gasglühlicht Akt.-Ges. (Auerges.). 55, Chancery Lane, London.
19,672. Metallic filaments for glow lamps (C.S.). I.C. Aug. 2, 1907, Germany. Accepted Sept. 9, 1908. Ges. für Verwertung Chemische Produkte, m. b. H., 55, Chancery Lane, London.
21,197. Fittings for tubular incandescent lamps. Sept. 24, 1907. Accepted Sept. 2, 1908. D. Assersohn, 7, Southampton Buildings, London.
23,786. Incandescent lamps. Oct. 28, 1907. Accepted Aug. 19, 1908. E. A. Gimingham, Birkbeck Bank Chambers, London.
24,027. Arc lamps (C.S.). I.C. Sept. 7, 1907, Germany. D. Trinar and K. von Dreger, 7, Southampton Buildings, London.
24,635. Arc lamps. Post dated April 3, 1908. Accepted Sept. 16, 1908. W. A. Legge, 65, Chancery Lane, London.
27,412A. Arc lamps. Jan. 13, 1908. Accepted Sept. 16, 1908. H. Bevis and A. E. Angold, Peel Works, Adelphi, Salford. (D.A. Dec. 12, 1907.)
620. Lamp clusters (C.S.). Jan. 10, 1908. Accepted Sept. 16, 1908. W. Fairweather, 65, Chancery Lane, London. (From Benjamin Electric Manufacturing Co., U.S.A.)
3,388. Incandescent lamps (C.S.). I.C. Aug. 7, 1907, U.S.A. J. W. Howell, 83, Cannon St., London.
4,568. Arc lamps (C.S.). Feb. 28, 1908. Accepted Aug. 19, 1908. C. A. Taylor and E. R. A. Broom, trading as The New Century Arc Light Co., Norfolk House, Norfolk Street, Strand.
8,421. Filaments for incandescent lamps (C.S.). I.C. May 13, 1907, Germany. Accepted Sept. 16, 1908. Wolfram-Lampen Akt.-Ges., 7, Southampton Buildings, London.
9,502. Arc lamps (C.S.). I.C. May 2, 1907, Germany. Accepted Aug. 26, 1908. Allgemeine Elektricitäts Ges., 83, Cannon Street, London.
11,599. Incandescent filaments from vegetable oil and resins (C.S.). I.C. Sept. 6, 1907, Germany. K. Rittersberg and H. Rubert, 67, Knesebeckstrasse, Charlottenburg, Germany.
12,630. Pocket lamp (C.S.). June 12, 1908. Accepted Sept. 9, 1908. P. M. E. Bourgeois and C. H. Bourgeois, 65, Chancery Lane, London.
12,968. Filaments for glow-lamps. June 17, 1908. Accepted Sept. 9, 1908. H. Kuzel, 322, High Holborn, London. (Addition to 28,154/04.)
14,910. Protective covers for glow lamps (C.S.). I.C. June 1, 1908, Germany. Accepted Sept. 16, 1908. Siemens-Schuckertwerke G. m. b. H., Queen Anne's Chambers, Broadway, Westminster.
17,419. Arc-lamp electrodes (C.S.). I.C. Sept. 3, 1907, U.S.A. G. M. Little, Westinghouse Building, Norfolk Street, Strand.
17,421. Arc-lamps (C.S.). Aug. 20, 1907, Germany. Körting and Matheson Akt.-Ges., 24, Southampton Buildings, London.
17,535. Arc-lamps (C.S.). I.C. Aug. 21, 1907, Germany. Allgemeine Elektricitäts Ges., 83, Cannon Street, London.
17,618. Refractory conductors (C.S.). I.C. Aug. 24, 1907, U.S.A. W. C. Arsem, 83, Cannon St., London.
17,619. Refractory conductors (C.S.). I.C. Aug. 24, 1907, U.S.A. C. T. Fuller, 83, Cannon St., London.
17,620. } Refractory conductors (C.S.). I.C. Aug. 24, 1907, U.S.A. W. D. Coolidge, 83, Cannon St., London.
17,621. }
18,054. Incandescent lamps (C.S.). I.C. Sept. 16, 1907, U.S.A. W. C. Arsem, 83, Cannon St., London.

II.—GAS LIGHTING.

17,998. Support for incandescent mantles. Aug. 8, 1907. Accepted Aug. 19, 1908. I. Sherwood, 40, Howard Street, Birmingham.
19,100. Incandescent mantles. Aug. 24, 1907. Accepted Aug. 26, 1908. J. Bernheimer and A. Gut, 6, Lord Street, Liverpool.
24,405. Inverted incandescent lamps or lanterns. Nov. 4, 1907. Accepted Sept. 16, 1908. F. Blank, 70, Chancery Lane, London.
24,878. Lanterns for gas-lamps. Nov. 9, 1907. Accepted Sept. 16, 1908. J. Gunning, Birkbeck Bank Chambers, London.
25,240. Inverted incandescent burners. Nov. 14, 1907. Accepted Aug. 26, 1908. Sunlight and Safety Lamp Co., Ltd., and T. B. Smith, 5, Corporation Street, Birmingham.

27,778. Holders for mantles. Dec. 17, 1907. Accepted Sept. 16, 1908. W. B. Brooker, 62, Stanley Road, Bootle, near Liverpool.

7,309. Controlling gas supply to lamps at a distance (C.S.). I.C. July 23, 1907, Germany. Accepted Sept. 9, 1908. G. Himmel, 18, Southampton Buildings, London.

7,318. Controlling gas supply to lamps at a distance (C.S.). I.C. Feb. 3, 1908, Germany. Accepted Sept. 16, 1908. G. Himmel, 18, Southampton Buildings, London. (Addition to 7,309/08.)

7,840. Lighting attachments for gas and acetylene burners (C.S.). I.C. Aug. 10, 1907, U.S.A. Accepted Sep. 2, 1908. C. J. Larkin, 72, Cannon Street, London.

9,276. Inverted incandescent lamps (C.S.). April 29, 1908. Accepted Aug. 26, 1908. M. Graetz, 18, Southampton Buildings, London.

9,892. Pressure-controlled igniters (C.S.). May 6, 1908. Accepted Sept. 9, 1908. E. Zickwolff, 31, Bedford Street, Strand.

12,487. Lighting and extinguishing burners by varying pressure in mains (C.S.). I.C. June 11, 1907. Accepted Sept. 16, 1908. J. R. Dupov, 53, Chancery Lane, London.

14,307. Inverted incandescent lamps for railway carriages, &c. (C.S.). I.C. Sept. 7, 1907, Germany. The Firm Ehrich & Graetz, 111, Hatton Garden, London.

15,549. Incandescent mantles (C.S.). July 22, 1908. Accepted Sept. 16, 1908. S. Cohn, 11, Southampton Buildings, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

20,288. Candle emitting coloured light. Sept. 11, 1907. Accepted Aug. 19, 1908. R. Scheuble, 18, Southampton Buildings, London.

23,818. Control of light-producing agents (arcs, limelight, &c.) for optical lanterns. Oct. 29, 1907 Accepted Aug. 26, 1908. G. Robson, 21, Rochdale Road, Leyton, Essex.

27,581. Lamps for churches, &c. Dec. 14, 1907. Accepted Aug. 19, 1908. M. Shrensky, 55, Market Street, Manchester.

1,206. Lighting lamps and lanterns. Jan. 18, 1908. Accepted Sept. 2, 1908. H. S. Cooke, 502, City Road, Edgbaston, Birmingham.

1,277. Burning paraffin wax, &c., for illuminating, &c. (C.S.). Jan. 18, 1908. Accepted Sept. 2, 1908. The New Transvaal Chemical Co., Ltd., and P. Destefani, 7, Southampton Buildings, London.

4,461. Filaments for lighting and heating (C.S.). I.C. June 10, 1907, France. Accepted Sept. 16, 1908. G. Michaud and E. Delasson, 7, Southampton Buildings, London.

5,209. Acetylene flare lights (C.S.). March 7, 1908. Accepted Aug. 19, 1908. C. C. Wakefield, 111, Hatton Garden. (Addition to 11,758/05.)

17,788. Matter for impregnating torches (C.S.). I.C. Aug. 25, 1907, Germany. T. Toccaceli, Carlton. Buildings, Paradise Street, Birmingham.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.—Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

An Association of Car-Lighting Engineers was formed in Chicago on Aug. 24th and 25th; the object of the Association appears to be the study of all matters connected with the illumination of trains and tramcars, and a number of prominent railroad electrical enigneers will participate.

The *Electrical Testing Laboratories* of New York write to us to state that the meeting of lamp-testers recently held in that city, and mentioned on p. 784 of *The Illuminating Engineer*, was attended by the inspectors in the employ of this company.

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The ILLUMINATING ENGINEER
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Edited by LEON GASTER

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EDITORIAL.

The second Annual Convention of the Illuminating Engineering Society.

The Second Annual Convention of this society was held in Philadelphia during the 5th and 6th of October. It is hardly necessary to state that the meeting has been very successful and that the enthusiasm of the members was evinced both by the exceptional character of the attendance and the standard of the papers read. Indeed, it is probable that few societies could boast of receiving a collection of papers covering such a wide area and containing the results of so much valuable original investigation at their annual meeting. The present years' success again proves, to quote a historic phrase of one of our contemporaries, that "the critics have turned out to be windbags."

Unfortunately, we still observe from time to time, instances, as exemplified by an editorial note in our esteemed contemporary *The Electrical Review* of October 16th, in which the writer proves to be unacquainted with the great work that is being done. In the case of the note to which we refer, he comments upon the attitude of the architect in the United States towards the illuminating engineer, and the tone of his remarks is such as to give the entirely erroneous impression that co-operation between the two professions is not desired.

We do not hesitate to say that no one in a position adequately to judge the conditions in the United States in this respect will endorse this suggestion, founded apparently upon one or two recent isolated utterances. There have been, it is true, many conferences between illuminating engineers and architects in which the views most intimately appealing to both have been put forward, but this frank discussion is desirable and does not in any sense indicate enmity. On the contrary, members of both professions who have taken part in the discussion of recent papers, though naturally differing on many points, have almost invariably agreed in this, that the architect and illuminating engineer could do very much to help one another, and that co-operation was both feasible and

desirable. In this connexion the paper by Mr. Perot, read at the Second Annual Convention of the Illuminating Engineering Society, and abstracted in this number, furnishes one more example of the current feeling on this point, for he suggests that the Society should undertake the tabulation of data regarding new illuminants and the lighting of existing buildings for the benefit of the architectural profession.

We think that anyone who has studied our own remarks on this question in previous numbers will understand that we merely desire that architects and lighting engineers should learn as much as possible about the conditions by which both are guided, and needless to say we recognize the standpoints of those in both professions, and wish them to receive full expression.

But apart from the question we have been discussing we cannot help thinking that a comment of this kind, which ignores all but one aspect of illuminating engineering, is singularly inappropriate at the present moment.

The Illuminating Engineering Society have issued a series of papers of quite exceptional merit, and showing very clearly the wide scope of the subject.

We publish elsewhere a complete official list of the eighteen papers read on this occasion, and we are reproducing a selection that, though necessarily curtailed, may serve to indicate their value as a whole; we hope to proceed with the publication of others in our next number, accompanied by some account of the discussion.

The now recognized and valuable work of the Illuminating Engineering movement is supported by many of the greatest authorities on lighting in Europe and America, and therefore we, who are in a position to quote facts and figures in support of our views, are not likely to be discouraged by the mere reiteration of unworthy epithets. This trivial and flippant method of brushing aside pertinent inquiries is only a confession of weakness on the part of our critics.

We confess that we find it a little difficult to understand the present attitude of this particular journal, which in previous issues declared that "there is every reason to believe that the illuminating engineer has come to stay...," that "those who are in any way interested in the design of and manufacture of shades.....may be advised to note very carefully what this new form of scientist has to say," and that "there is no doubt that the *science* of illuminating engineering is going to open up a new field of commercial exploitation," &c.

The New Illuminants and the Illuminating Engineer.

Turning to another of the remarks of our critic, we feel bound to protest against what appears to us his peculiarly narrow outlook when he suggests that illuminating engineering would deposit the station engineer in a "yawning gulf" caused by the introduction of the new lamps, and that the scope of the work of the illuminating engineer is therefore more curtailed than in the days when only carbon filament lamps were available!

In reality it is this very multiplication of different sources of light that supplies a very cogent argument for his existence. When only a choice between a few illuminants was possible, the assistance of an expert was relatively less vital. But at the present day it is literally impossible for any but an expert to keep in touch with the maze of modern developments.

Experience in the United States has shown that the illuminating engineer, so far from being a thorn in the flesh of the station engineer, is looked upon as one of the best friends he can possibly have, and so well is this recognized that, as stated in our last number, the Edison Electric Illuminating Co., of Boston, have organized a department of illuminating engineering for the benefit of their consumers. Bearing in mind the work already

done by us and others in this country, we think it may at least be conceded that those who write on the subject of illuminating engineering should take reasonable pains to bring their point of view up to date.

Street-lighting.

There are probably few questions in illuminating engineering that are now receiving such continuous and concentrated attention as the subject of street-lighting. But a short time ago we were discussing the report of Mr. A. A. Voysey on the City lighting of London, and recording the visit of Dr. Bell, Mr. Wrightington, and others, who were touring the chief European cities with the object of studying the merits of existing systems.

Some fruits of these studies are given by these two gentlemen in their contribution to the Annual Convention of the Illuminating Engineering Society. Dr. Bell's Presidential Address deals broadly with the subject, and Mr. Wrightington describes his impressions of the lighting by gas in Europe, which are, on the whole, encouraging, especially as regards the use of high-pressure.

An interesting point to which he draws attention is the greater assistance that is derived by the street-lighting in the United States from the efforts of private enterprise in the shape of signs, shop-lighting, and local arc-lights and gaslights, &c. So far as it can be relied upon, assistance of this kind would appear to be very beneficial, for it leads naturally to convenient methods of diffusing the light and the use of small distributed units. This question of the size of units desirable in street-lighting and their distribution seems to be one on which much discussion may be expected in the near future, for the possibility of applying many different types of illuminants to street-lighting which have not previously been much utilized in this connexion is becoming generally realized.

At the same time the question has received considerable attention in Berlin, as will be seen from the recent contributions of Prof. Drehschmidt and Dr. L. Bloch, which we reproduce in abstract in this number. The existing methods in Berlin are of particular interest, and the development and relative merits of high-pressure inverted gaslighting and the new white flame arcs will be closely watched by engineers in other countries.

We are glad to notice that at a meeting of the City of London Corporation on October 22nd it was decided to send a deputation to investigate the street-lighting methods of some of the principal European towns, before extending the use of either high-pressure gas or flame arc lamps for street-lighting purposes in this city.

We trust that the result of this investigation will be of great value, and will contribute to improve the lighting of London so that it may become in time one of the best-lighted towns in existence, instead of, as at present, leaving very much to be desired in this respect.

The International Electrotechnical Commission.

The main point of interest to our readers in the proceedings of the Council of the International Electrotechnical Commission, which assembled in London on October 19th, has been the proposed international unit of light; to this reference was made in our September and October numbers.

The decision of the Council of the Commission, that the question be referred back for reconsideration by the electrotechnical committees of the different countries, in order that arrangements may be made for the needs of gas and electrical industries to be jointly considered, will we think, be regarded as a wise one.

A great deal of very excellent work in the direction of promoting an international unit has recently been done in the United States and elsewhere, and

we do not think for a moment that this work will lose in value from the fact that no immediate final decision has been taken. We are particularly in sympathy with the expressed wish of the Council that this matter should be made the subject of discussion between those representing gas and electrical interests. For only by such co-operation it is reasonable to believe that a truly international unit can be arrived at.

Fortunately, we have abundant evidence available that such co-operation is possible. Dr. Humphreys, the President of the Institution of Gas Engineers in the United States, has just presented a very important report on this subject, which we reproduce elsewhere, and which describes the co-operation between the Institutions of Gas and Electrical Engineers in that country, and the Illuminating Engineering Society. In the same way it was interesting to observe from the recently issued report of the Deutscher Verein von Gas- und Wasserfachmännern, that gas engineers in Germany are considering the possibility of adopting or modifying the recommendations of the Verband Deutscher Elektrotechniker regarding the photometric comparison of arclamps.

It seems to us a pity that the recommendations of a body such as the International Commission of Photometry, which has done such exceedingly valuable work in defining photometric quantities and units, should fail to receive the general recognition among all classes of engineers that their importance demands, simply because the members of the commission are almost exclusively drawn from the gas profession, and the Commission has no truly official international character. It seems, by the way, to be a curious anomaly that the gas referees, who are the official testers of gas in this country, should not have been asked to appoint a representative on this commission.

The necessity for more complete co-operation between the representatives of different industries, therefore, may be said to furnish good ground for the council of the commission not having come to any premature conclusion as to international standards. Another reason for deprecating hasty action lies in the more or less incomplete state of the data connecting the values of the various units. The system of co-operation between the official laboratories of different countries has already accomplished valuable work, but yet there are still points to be settled, and therefore it is better not to commit ourselves to international decision. For instance, the recently raised question of the method of measuring the humidity of the air in which the pentane standard is burned in itself compels reconsideration of the proposal of the French national committee; we ourselves would like to see such questions thrashed out yet a little further, until there is no longer any room for doubt as to what the relations between the existing standards really are.

For the above reason we have supported the reconsideration of the proposal, and think that the decision of the Council of the Electrotechnical Commission will be regarded as a wise one; we feel confident that the perseverance in the present concerted efforts between the laboratories of different countries will shortly lead to more satisfactory conditions. Judging from the goodwill and friendly attitude shown by the different delegates towards genuine co-operation, much may be expected from this international gathering in the future. Science has shown once more that it knows no national boundaries, but is international in the true sense of the word.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 887) continues his treatment of different photometrical instruments, describing, in the present section, the PHOTOMETERS designed by RUMFORD and FOUCOULT, and some of the methods of work of these investigators.

Dr. M. Corsepius (p. 895) completes his article dealing with the GLOBE PHOTOMETER. This article, it will be remembered, is mainly concerned with a NEW METHOD OF OBTAINING THE MEAN HEMISPHERICAL CANDLE-POWER of sources with this instrument. Among other investigations the author studies the effect of tilting the special vessel that serves to obstruct the light in one hemisphere, and arrives at the result that, for the determination of mean lower hemispherical candle-power, this source of error will not be of serious consequence under practical conditions.

Dr. C. V. Drysdale (p. 899) continues his series of articles on the LAWS AND MEASUREMENT OF RADIATION. In the present section he briefly explains Newton's Law of Cooling, and the experiments of Dulong and Petit, and gives some account of the work of Melloni on thermal radiation. Lastly, he gives a diagram illustrating the distribution of energy in the spectrum, as obtained by Tyndall with a rock-salt prism.

Mr. H. T. Harrison (p. 901) contributes an article on the COST OF STREET-LIGHTING. He discusses the general conditions to be observed in order to secure a uniform illumination by gas or electric lamps, and gives some tables showing the connexion between the number of posts and the cost per annum, &c., under various conditions.

The **Special Section** in the present number (p. 913) is given up to the series of papers recently delivered at the SECOND ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY. A complete official list of these papers is given, and several of them are dealt with in some detail.

The contribution of **Mr. L. B. Marks** (p. 921) deals with the ILLUMINATION OF THE CARNEGIE LIBRARIES in New York City in a very complete manner. The general conditions that must be respected in designing such an installation are discussed and full particulars are given of the exact fixtures used, and the method according to which they are distributed on the various floors of the building.

Dr. A. C. Humphreys (p. 917) gives an account of the work of the COMMITTEE ON NOMENCLATURE AND STANDARDS OF LIGHT, consisting of representatives of the Institutions of Gas and Electrical Engineers in the United States and the Illuminating Engineering Society. It is pointed out that the units of light in common use among those representing the gas and electrical interests differ by about 4 per cent, and the Committee therefore propose that a national unit, intermediate between these two values, should be adopted. This is the more to be desired, because it is expected that the international unit of light, when it is finally accepted, will approach the new American unit very closely.

Dr. A. H. Elliott (p. 921) gives an account of an exhaustive series of TESTS ON DIFFERENT VARIETIES OF PETROLEUM, from the point of view of obtaining a suitable photometric standard. The results are, on the whole, favourable; many of the lamps tested preserved a very constant value over a considerable interval of time, provided that certain conditions are complied with.

Mr. J. E. Woodwell (p. 938) discusses ILLUMINATION FROM THE PHYSIOLOGICAL STANDPOINT. He seems to think that the main danger to be avoided in illuminants is too bright

intrinsic brilliancy, and describes the general effect of such sources on the pupil-aperture and the retina. He considers that the limits of permissible brightness that have been set by previous writers are none too low, and would himself prefer that the brightness should not exceed about 0·2 candle-power per square inch of radiating surface.

Mr. E. G. Perrot (p. 941) deals mainly with some of the aspects of illuminating engineering that appeal to the architect. In conclusion, he makes the suggestion that the Illuminating Engineering Society should prepare tables relating to existing illuminants and the conditions of illumination in certain buildings, &c., and other data, of which the architectural profession are in need.

Mr. L. J. Lewinson (p. 943) describes an exhaustive series of tests on daylight illumination carried out in the Electrical Testing Laboratories in New York. He gives some curves illustrating the variation of moonlight and of natural sunlight during different parts of the day, and discusses the effects of clouds and other climatic conditions.

Attention may be drawn to the OBITUARY NOTICE of **Sir George Livesey** on p. 890.

On p. 892 will be found an abstract of the REPORT OF THE ELECTROTECHNICAL COMMISSION, accompanied by a photograph of the various representatives of different countries who took part in the proceedings. The chief point of interest from the standpoint of illuminating engineering is the subject of an international unit of light; the Commission make no immediate decision on this matter, but refer the subject back to individual committees in order that some arrangement may be recommended that will be convenient both to the gas and electrical industries of different countries.

An article on p. 905 discusses the LIGHTING OF LIGHTHOUSES AND BUOYS BY ACETYLENE. Some account is given of the different methods by which beacons and buoys are lighted, the writer remarkng that it is mainly in this direction that acetylene has proved itself convenient. Special mention is made of the use of dissolved acetylene which, in conjunction with a special valve opening and shutting with the heat of the sun, has been widely employed in Sweden. This article is followed by an account of the MANCHESTER ELECTRICAL EXHIBITION, viewed from the standpoint of illuminating engineers (p. 909).

Among other papers dealt with in this number may be mentioned that by **MM. Laporte and Broca** (p. 947) dealing with the EFFECTS OF DIFFERENT ILLUMINANTS ON EYESIGHT. These experiments were carried out on electric incandescent glow-lamps and a mercury-vapour lamp, and included tests of visual acuity, speed of reading, effect on pupil-aperture and the production of retinal images. The authors' experiments suggest the conclusion that the difference in the colour of these sources is of little consequence, and that brightness is the important factor.

The recent papers by **Prof. Drehschmidt** and **Dr. L. Bloch**, abstracts of which appear on pp. 951 and 953 respectively, are of special interest, in that each deals with the STREET-ILLUMINATION OF BERLIN. Some particulars are given of the lighting by high-pressure inverted gas-lights and the new white flame arc-lamps using vertical carbons, the conclusion being, however, reached by DR. L. Bloch that it is not possible to state definitely that either method is invariably preferable; much depends on the local conditions and the improvements in both illuminants approximately balance each other.

Another article (p. 956) contains a résumé of the discussion that has recently been taking place in Germany on the subject of the MERITS OF HIGH-PRESSURE GAS AND HIGH-PRESSURE AIR, for the purpose of improving the efficiency of incandescent gas-lighting.

Mr. A. Denman Jones writes discussing the methods of studying the ABSORPTION OF ARC-LAMP GLOBES, recently proposed by Prof. J. T. Morris and Dr. E. W. Marchant.

At the end of the magazine will be found the usual **Review of Current Literature dealing with Illumination** (p. 961), and the **Patent List** (p. 965).

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

(*Continued from p.* 800.)

The Rumford Photometer.—Lieut.-General Sir Benjamin Thompson, Count of Rumford, who demolished the theory of caloric by proving that heat can be generated at the expense of mechanical work, wrote to Sir Joseph Banks on Dec. 20th, 1792, a short account of 'A Method of Measuring the comparative Intensities of the Light emitted by Luminous Bodies.' This consisted in observing the shadows cast by a rod on a sheet of white paper. He went into some detail, but on March 1st, 1793, he wrote a much longer letter, which, with the first, was communicated to the Royal Society.*

He described a carefully elaborated instrument, and proposed, if he might do so, "without being suspected of affectation," to "dignify it with a name, and call it a photometer."

The ordinary text-books, whether on physics or photometry, illustrate and describe the Rumford photometer as an arrangement by which two lamps on a table cast two widely separated shadows of a rod on a large screen. Writers of textbooks have a habit of endeavouring to simplify descriptions of apparatus, at the expense of accuracy. This primitive arrangement has the sole merit that it is an example of an arrangement where stray light reflected from the walls of the room or from the ceiling, has but little harmful effect, for it dilutes the two shadows equally. The textbook arrangement leaves out any consideration of the position of the observer, who apparently wanders round the table in the full glare of the lamps. Even so careful a writer as Palaz* says that "generally the two lights are moved along a divided scale perpendicular to the screen, but sometimes in any manner whatever; we then neglect the law of inclination.... In practice, if we wish to measure rapidly the intensity of a luminous source, say to within 10 or 15 per cent, the Rumford photometer is very valuable, in that it is easy to set up, but it makes no pretension to giving results which are rigorously exact." This is not fair to Rumford. He paid the greatest possible attention to the angles of incidence, and nowhere speaks of moving lights along a scale perpendicular to the screen. The Rumford photometer was an admirable instrument, and the inventor was a highly skilled observer.

The complete apparatus for which the term Rumford photometer should be reserved (using the expression the Rumford principle for the bald use of two lights and the shadow of a rod), consisted of two cylinders in a carefully blackened box at the meeting point of two tables. One table was 12 ft. long, the other 20 ft., and each was

* Thompson, *Roy. Soc. Phil. Trans.* 1794, and *Phil. Trans.* Abridged, Vol. xvii. The paper is also to be found in Rumford's Collected Works.

* Palaz, 'Traité de Photometrie Industrielle,' p. 24, or Patterson's translation, p. 26.

10 in. wide. The box had two short tubes through which the light passed on to a paper screen. The observer stood between the tables and examined the screen through a third opening between the two tubes. The apparatus is shown in plan in Fig. 48.

"Finding it very inconvenient to compare two shadows projected by the same cylinder, as these were either necessarily too far from each other to be compared with certainty, or when they were nearer they were in part hid from the eye by the cylinder, to remedy this inconvenience I now make use of two cylinders....and when the two lights....are properly placed, these two cylinders project four shadows upon the white paper...., which I call the field of the instrument, two of which shadows are in contact precisely in the middle of that field, and it is these two alone that are to be attended to. To prevent the attention being distracted by the presence of unnecessary objects, the two outside shadows are made to disappear.... they fall....upon a blackened surface, upon which they are not visible."

"As the diameters of the shadows of the cylinders vary in some small degree in proportion as the lights are.... brought nearer to or removed farther from the photometer....I have added to each a vertical wing;....by means of these wings....the widths of the shadows are augmented so as to fill the whole field of the photometer."*

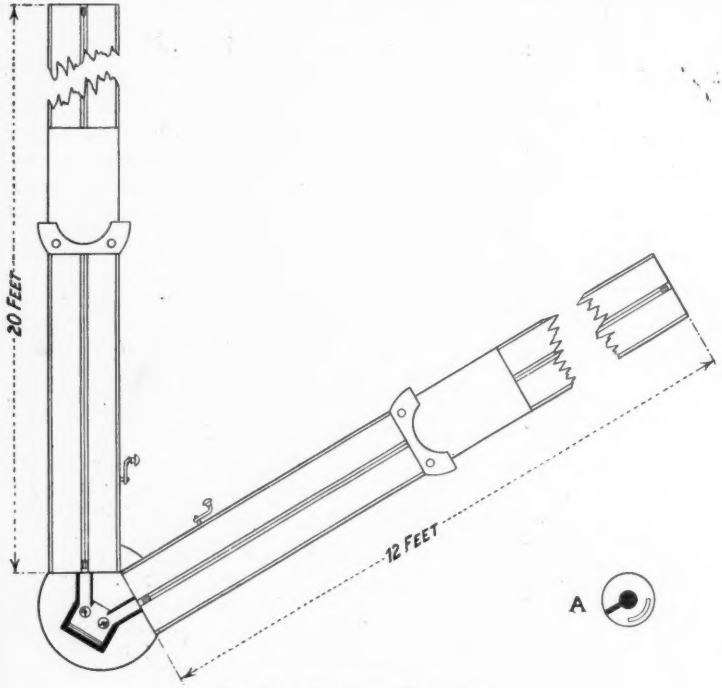


FIG. 48.—Rumford's Photometer.

A cylinder with its wing is shown on a larger scale at A, Fig. 48. Count Rumford describes the apparatus in great detail. The lamps were moved by cords and winches, the handles are seen in the illustration. The sliding motion of the lights was "perfectly soft and gentle," an important matter, greatly neglected in many modern labora-

* Thompson, *Roy. Soc. Phil. Trans.* 1794, p. 73, and Abridged *Phil. Trans.*, Vol. lxxxiv. p. 362.

tories. The scales on the tables were graduated for direct reading.

Rumford's 'Experiments upon the Resistance of the Air to Light' appeared to yield no result, but they, indeed, reveal the remarkable accuracy of his work, seeing that he was using candles and oil lamps. These experiments, in fact, serve only to show the errors of the observations, for under the conditions of the experiments he was doing nothing more than testing the law of squares. The following figures are taken from the table of his fifth to his twelfth experiment :—

Distance of light in inches.	203	198·3	202·1	204	198	192·2	191·2	192·4.
Calculated distance.	202	200·4	201·6	203	200	191	190·2	192.

Lest it may be imagined that he was a man who could "fudge," the following extract will prove the contrary, and is worth quoting at length :—

"In order that in judging of the quality of the shadows my mind might be totally unbiassed by my expectations, or by any opinions I might previously have formed with respect to the probable issue of the various experiments, keeping my eye constantly fixed on the field of the photometer, and causing the light, whose corresponding shadow was to be brought to be of equal density with the standard, to move backwards and forwards, by means of the winch which I had constantly in my hand, as soon as the shadows appeared to me to be perfectly equal, I gave notice to an assistant to observe, and silently to write down, the distance of the lamp or candle, so that I did not even know what that distance was till the experiment was ended, and till it was too late to attempt to correct any supposed errors of my eyes by my wishes or by my expectations, had I been weak enough to have had a wish in a matter of this kind. I do not know that any predilection I might have had for any favourite theory would have been able to have operated so strongly upon my mind,....but this I know, that I was very glad to find means to avoid being *led into temptation*."*

The Foucault Photometer.—From the Bouguer to the Foucault photometer there was but a step. Foucault shielded the transparent screen from stray light with a box, and provided an adjustment by which the dividing partition, nearly but not quite touching the transparent screen, could be set so that the two illuminated halves could be made to meet with hardly any shadow or bright space. Fig. 49 is copied from Foucault's original illustration.† He found that two candles taken from the same packet varied at each instant, and gave the same light only accidentally, and almost always showed "a shocking inequality." He therefore used a bunch of seven.

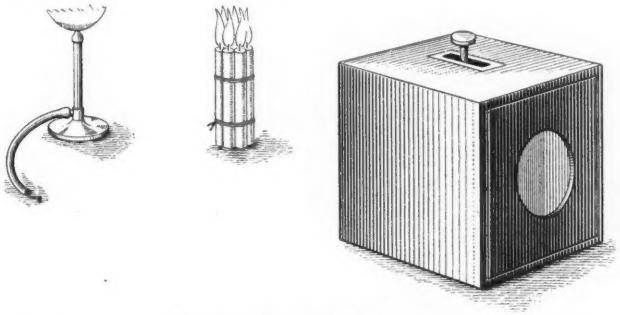


Fig. 49.—Foucault's Photometer.

Foucault attached great importance to the construction of the screen, and recommended a layer of starch on glass.

(*To be continued.*)

* Thompson, *loc. cit.*, p. 90.

† L. Foucault, 'Recueil des Travaux Scientifiques,' 1878, p. 103.

SIR GEORGE LIVESEY.

It is with great regret that we record the death of Sir George Livesey, which occurred on Sunday morning, October 4th, at the age of seventy-four years.

It is impossible here to enter upon so vast a task as a detailed account of Sir George's life and work; they are bound up with the progress of the South Metropolitan Gas Company, whose service he entered in 1848.

But it is perhaps permissible to take this opportunity of referring to a few of the qualities which raised Sir George Livesey to his eminent position, and were so effectual in gaining the respect and affection of those who served under him.

His patient and thorough habit of mind led him to form conclusions cautiously; yet his decision once taken, nothing could shake his resolution in the pursuit of a course of policy which he believed to be correct.

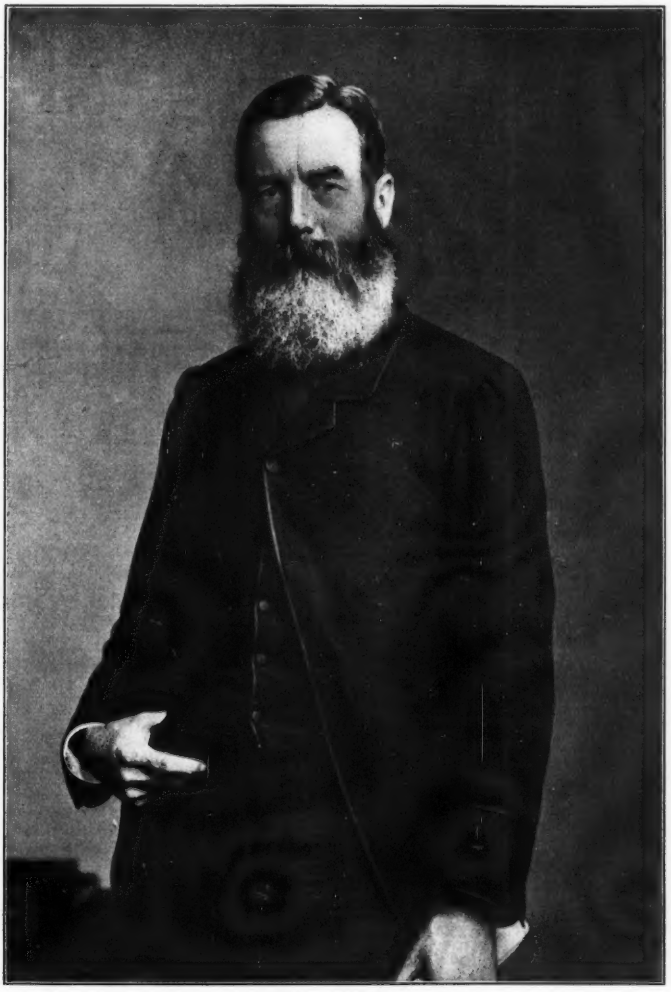
Sir George Livesey united with his scientific attainments a wide knowledge of human nature and rare administrative ability. His power of sympathy with those working under him led to a feeling between employer and employee such as it is given to few to inspire; the bearing of his unique work on social problems will be recognized and valued in the future perhaps even more than to-day. To all details of his business Sir George Livesey brought the same wide view, the same strong sense of justice, and the same broad sympathy with the needs of consumer and supplier alike.

When the writer, a few years ago, sought his advice on the prospects of illuminating engineering, Sir George Livesey found time amidst his unceasing duties to listen with ready patience and sympathy, and to give him the benefit of his great experience. With a characteristic wideness of view he explained that, although it was to him inconceivable that he could ever be other than a representative of gas interests, yet he believed in the need for greater facilities for an exhaustive study of the true merits of the different illuminants, and cordially agreed that the subject of illumination deserved fuller attention.

We desire to offer our respectful sympathy to Lady Livesey and the family in the great loss that they have sustained—a loss that is shared by the nation.

The foundations of Sir George Livesey's work were too truly laid in his lifetime to suffer now; but he himself is missed and regretted by all who ever knew him.

THE EDITOR.



[Reproduced by permission of the *Journal of Gas Lighting*.
Portrait taken after the South Metropolitan Gas Works Strike in 1889.
SIR GEORGE LIVESEY.

The International Electrotechnical Commission.

THE first meeting of the Council of the International Electrotechnical Commission was held on Monday, October 19th, 1908, in the Medical Hall on the Victoria Embankment, when an address of welcome was delivered by the Right Hon. A. J. Balfour, M.P., and Sir John Gavey, C.B., took the chair. Prof. Elihu Thomson was elected President of the Commission.

One of the main questions that came before the Commission was that of devising an improved system of electrical nomenclature and symbols, and their subsequent publication. It was proposed that a complete glossary of technical terms in different languages should also be prepared, indexed in alphabetical order.

On these questions the decision has been arrived at that, for the present, the attention of the different electrotechnical committees shall be concentrated on the definition of terms for subsequent compilation in the form of an official glossary, which should afterwards be duly authorized by the Council for publication. In so doing, however, each committee will, wherever possible, utilize the work already done by others, due credit being given in each case.

It was also decided that in cases in which the International Electrotechnical Commission has to make use of measurements in its work, the metric or Centimetre-Gramme-Second system shall be employed, but that, in order to meet the needs of those countries in which the metric system is not employed, individual committees shall have the right to add the equivalent value in brackets.

A very important proposal was submitted by the French Committee for discussion relating to the suggested international agreement upon a standard of light.

The exact terms of this proposition were as follows :—

The French Committee, recognizing the advantage which would be gained by the international agreement as to the standard of light, and seeing that the first investigations with regard to an absolute unit of white light have received official sanction by the decisions of the International Commission on Electrical Units of May 2nd, 1884, and of the International Congress of Electrical Engineers of August 31st, 1889, admitting that the present position of affairs in regard to the standard of light is similar to that which existed in 1884 with regard to the ohm, desires to put forward the following suggestions :—

"Whilst awaiting further investigations into the question of the absolute standard of light, that for practical requirements of standard of light be provisionally adopted under the name of "international candle," related in the following manner of the various standards at present in use, and which take cognisance of the decisions of the International Commission on Photometry, held at Zürich in 1907.

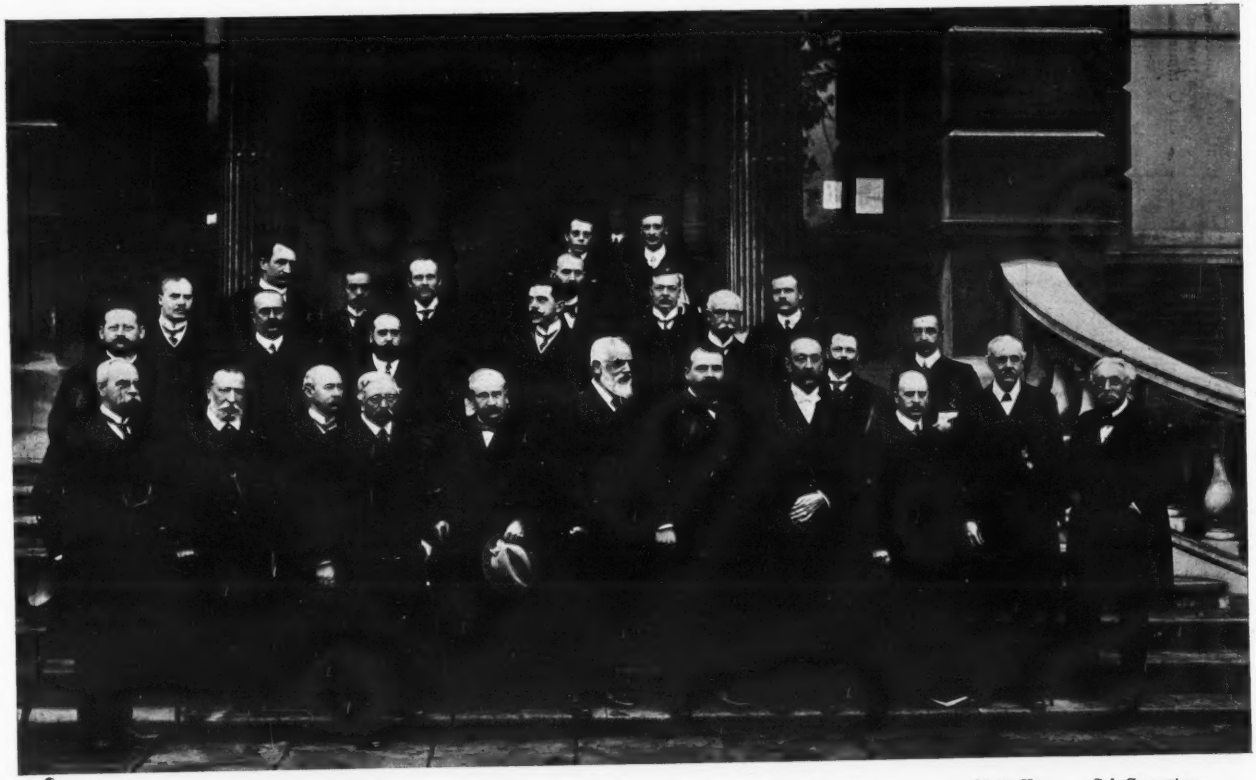
1 International Candle = 0·104 Carcel.
1 International Candle = 1·12 Hefner.
1 International Candle = 0·102 Vernon Harcourt.
1 International Candle = 0·98 Candle the Bureau of Standards.

The Council of the Commission, however, were wisely of opinion that this proposition should be adjourned in order to allow the different Electrotechnical Committees to be more completely informed on the subject, and also recommend that these committees should endeavour to arrange matters in such a manner as to satisfy the needs of both the gas and electrical industries in the different countries.

The following is an official list of the representatives of different countries taking part in the Commission :—

Argentine Republic		
Australia	...	Mr. C. W. Darley.
Brazil ...	...	Sr. H. Vascoucellor.
Canada ...	...	Mr. Ormond Higman.
Denmark	...	Mr. S. A. Faber, Prof. Abaslon Larsen.
France ...	...	M. Paul Boucherot. M. Ch. David.
Germany	...	Dr. E. Budde, Herr G. Dettmar.
Great Britain	...	Sir John Gavey, C.B., Prof. Silvanus Thompson, F.R.S.
Holland ...	...	Prof. Haga.
Hungary	...	Mr. Joseph Vater.
Japan ...	...	Dr. Osuke Osano, Mr. S. Kondo.

Mr. C. le Maistre, Acting Secretary.



Prof. S. P. Thompson, Official Delegate for Great Britain.

Sir John Gavey, Official Delegate for Great Britain.

Right Hon. A. J. Balfour.

Col. Crompton, Hon. Sec.

Members of the International Electrotechnical Commission.

Mexico ...	...	General Don J. M. Perez, Sr. Alfonso Castello.
South Africa	...	Mr. Lee Murray.
Spain ...	...	Sr. Madariaga, Sr. Montenegro.
Sweden ...	...	Prof. Svante Arrhenius.

Mr. Mailloux (U.S.A.), Mr. L. Gaster (Roumania), Mr. Maximo Croskey (Paraguay), Mr. Alex. Siemens, Mr. Robert Kaye Gray, Mr. Mordey (President of the Institution of Electrical Engineers), received special invitations to attend the meetings of the Council of the Commission, without vote.

The International Conference on Electrical Units.

THE Conference was opened on Monday, Oct. 12th, in the Rooms of the Royal Society, Burlington House, London, an address being delivered to the delegates by the Right Hon. W. S. Churchill.

At the first meeting a resolution was moved by Mr. A. P. Trotter to the effect that the fundamental electrical unit should be determined on the electro-magnetic system with reference to the C. G. S. units of length, mass, and time, and carried unanimously.

Prof. Warburg next proposed that the International ohm should be defined as the resistance of a specified column of mercury. This was agreed to after some discussion, but the question of the exact dimensions of the mercury standard was eventually referred to Committee.

At the second meeting of the Conference Dr. Glazebrook moved that the ampere be regarded as the second primary electrical unit. Dr. Glazebrook referred to the exactitude with which the ampere could be determined by electrochemical means, and pointed out that the determinations of the ohm and ampere were quite independent. This, of course, did not invalidate the use of standard cells and resistances for ordinary measurements.

Some discussion on the merits of the Clark and Weston cells as a means of defining the volt followed, but eventually the resolution that "the ampere is the second primary unit" was carried, and it was also agreed that specifications should be prepared by a committee relating to the mercury ohm, the deposition of silver for the purpose of determining the ampere, and the Weston cell.

Finally it was agreed that the international volt is to be a derived unit from the two primary units, the ampere and the ohm. The international volt is thus defined as the electrical pressure, which, when steadily applied to a conductor whose resistance is one international ohm, will produce a current of one international ampere.

At the third meeting the additional resolution "that the ohm is the first primary unit" was formally put to the Conference by Dr. Glazebrook and carried unanimously.

The Measurement of Mean Hemispherical Candle Power by the Aid of the Ulbricht Globe Photometer.

By Dr. M. Corsepius.

(*Continued from p.* 806.)

In the calculation on p. 806 it has been assumed that no upper screen is necessary. In the case of lamps provided with diffusing globes such a screen is still required, in spite of the use of the vessel, in order to cover the illuminating surfaces of the globe projecting from the vessel (see Figs. 4 to 6); but this constant of calibration is not affected thereby.

If, as explained above, we carry out two separate calibrations with and without the vessel respectively, the values of $I_{\circ}$ and $I_{\square}$ subsequently resulting from the use of the constants so obtained must ultimately be corrected by applying the corrections we have just worked out, and these, as we have seen, are extremely slight.

The effect of the introduction of foreign bodies on the integral brightness of the globe, and the difference between the two constants of calibration, can be calculated by the methods developed by Prof. Ulbricht. Thus in the case of small lamps the foreign body will consist of a hemisphere h, built out of copper sheet, and 30 centimetres in diameter; this consists of two separate portions, one a black circular disk, and the other a white hemispherical surface. In this case $a=a_1=0{\cdot}2$, and the difference amounts to about 3 per cent. But this quantity need not be

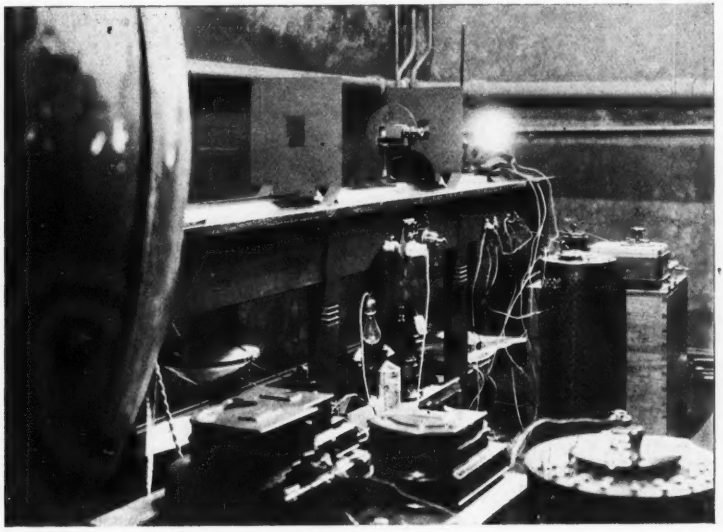


Fig. 3.—General View of Apparatus.

taken into consideration, for its effect is eliminated by means of the double calibration with and without the vessel. On the other hand, when one has become acquainted with the difference between the two values by a long series of experiments upon different types of lamps one can calculate the second constant of calibration from the first, and need, therefore, only make one determination. In either case, however, we are enabled to make use of an unscreened standard lamp for the purpose.

The photometrical apparatus is shown in Fig. 3. The position of the vessel G within the globe may be seen in the photographs represented in Figs. 2 and 4; Fig. 2 shows the smallest, and Fig. 4 the largest of the forms adopted.

I have also considered the possibilities of errors introduced by not keeping the circle of section strictly horizontal, under practical conditions. The mean hemispherical intensity of the upper hemisphere was determined in the case of the lamps mentioned in Table I., first with the face of the vessel truly horizontal, as in Fig. 4; secondly, hung slightly oblique, as in Fig. 5; and lastly, still more crooked, as shown in Fig. 6. As a result the value observed varied about 6½ and 17 per cent in the two cases. Such displacements of the vessel are, however, very obvious to the eye, and may easily be avoided without the help of any specially designed apparatus. One can, however, easily make assurance doubly sure by the aid of a plumb-line or level. In any case, however, a displacement, such as that shown in Fig. 5, would only give rise to an error of about 0·52 per cent in the final result.

For the purpose of determining the position of the radiant centre of illuminants I have availed myself of the variety of tester due to Ulbricht, and constructed by Stieberitz of Dresden; such an instrument, possessing two prisms and two view-holes, is shown in Fig. 7.

Fig. 8 shows an arc-lamp of the usual variety equipped with a highly transparent alabaster globe. The horizontal line indicates the position of the plane corresponding to the position of the radiant centre.

Although the glass is of such a transparent nature, it is worthy of note that the shadow of the carbons and the



FIG. 4.—Vessel truly Horizontal.



FIG. 5.—Vessel slightly Oblique.

guide-rods is clearly visible, the plane indicated lying in reality not as suggested by the line in question, but much lower. Even comparatively transparent glass therefore exerts a certain diffusing action. This fact may be deduced from the last row of measurements in the table previously mentioned.

Finally, it is of interest to make some reference to the effect of diffusing globes on the value of the mean hemispherical candle-power. Although the few figures given in the table hardly suffice to enable us to trace a definite

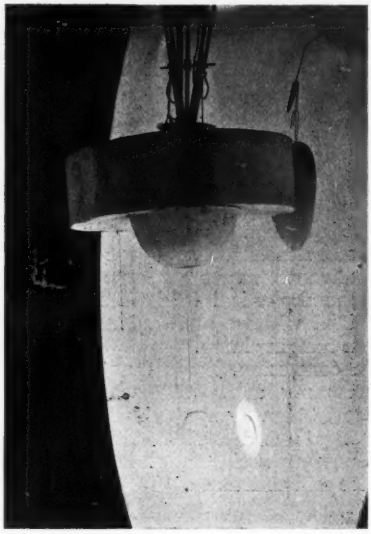


FIG. 6.—Vessel still more Oblique.

numerical connexion, there can be no question that the effect exists, and makes itself especially evident when hemispherical candle-power is considered.

Under the heading "k_g hem." are given the ratios between the mean hemispherical candle-powers, obtained without and with a diffusing glass globe respectively. We see at once that considerable differences are introduced between the ratios of the contributions in the two cases, and that, as Ulbricht has already shown, a determination of the mean hemispherical candle-power, using a clear glass globe, furnishes no indication as to what the same quantity, using a diffusing globe, will be. Under the heading "k_g spher." the corresponding ratios for the mean spherical candle-power are given. In this case the differences are distinctly lower.

We may conclude, therefore, that it is unwise to attempt the value of the mean hemispherical candle-power when a diffusing globe is used by the aid of a known coefficient of absorption of the glass, and a knowledge of the same quantity obtained for the naked source or for the source screened with clear glass. And it may be also remarked that the light from a naked arc-light is usually altered in two distinct ways when a diffusing glass globe is utilized, being affected not only by the absorp-

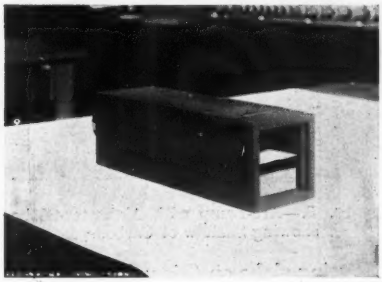


FIG. 7.—Apparatus for Determining Position of Radiant Centre.

tion of the glass, but also by the greater or less admission of air and the altered circulation, which often constitute quite as influential a factor as the former.

It must also be recognized that naked arc-lamps are now never used for practical purposes of illumination, and lamps with clear globes but very seldom. As we have seen, the effect of diffusing glass is such that measurements of the mean hemispherical intensity with clear globes afford no positive data as to the performances of the lamp in this direction. Even if we elect to measure the mean spherical intensity we do not actually avoid the same effects in practice, though the unknown effect of the globe on relation between the upper and lower hemispherical candle-power is eliminated.

On the other hand, the hemispherical candle-power in the lower hemisphere is in some cases the most important consideration, and such a measurement takes no account of the effect of the

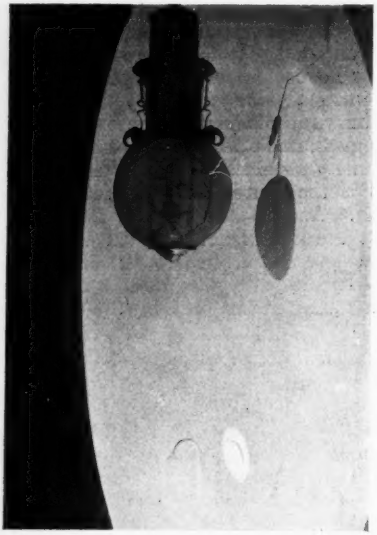


FIG. 8.—Arc-Lamp with Alabaster-Globe, showing Shadow of Carbons, &c.

diffusing globe on this value. In other cases—for indoor illumination, for example—the intensity in the lower hemisphere is by no means the only value to be considered.

In any case, whether we elect to measure the mean spherical or mean lower hemispherical intensity, we must take account of this diffusing action of the glass in a scientific manner, and cannot regard measurements using clear glass globes as effective for practical purposes.

On the whole it may justly be concluded from what has been said previously, that, as prescribed by the Verband Deutscher Elektrotechniker, *both* mean spherical and mean lower hemispherical candle-power should be measured, and the method of measurement described seems adapted to enable us to obtain both these quantities in a convenient and correct manner; measurements should also be carried out both with clear and diffusing globes.

It may be added that the vessel G may be placed above instead of below a source of light, its circle of section being maintained in the plane through the radiant centre as usual, thus enabling the lower hemispherical intensity to be obtained by means of a single measurement. This method has also the advantage that both the spherical and hemispherical intensities may be obtained without altering the position of the hanging lamp.

In conclusion, I must not omit to express my acknowledgment of the interest taken by Prof. Ulbricht in the investigations described in this article, and my appreciation of his valuable advice and assistance.

A CORRECTION.

We are requested to make a correction in the formulæ which appear in the article by Dr. M. Corsepius in *The Illuminating Engineer* for October on p. 806.

These formulæ should read as follows:—

$$f-f_1=\frac{F.\,a}{\pi}\left\{\frac{\cos^7\alpha}{(2\cos^2\alpha-1)^2\ (r-x)^2}+\frac{\cos^3\alpha}{4\,x^2}\right\}-\frac{F_1\,a}{\pi}\left\{\frac{\cos^7\alpha_1}{(2\cos^2\alpha_1-1)^2(r-x_o)^2}+\frac{\cos^3\alpha_1}{4\,x_o^2}\right\}$$

$$f-f_1=\frac{F.\,a}{\pi}\ \frac{\cos^7\alpha}{(2\cos^2\alpha-1)^2r^2}-\frac{F_1\,a}{\pi}\left\{\frac{\cos^7\alpha_1}{(2\cos^2\alpha_1-1)^2(r-x_o)^2}+\frac{\cos^3\alpha_1}{4\,x_o^2}\right\}$$

The Production and Utilization of Light.

The Laws and Measurement of Radiation.

By Dr. C. V. Drysdale.

(Continued from p. 824.)

We may now pass from the methods of measurement to the results which have been obtained, and which are of such great importance. A brief résumé only of the earlier work will be given, as it is to be found at greater length in standard works such as Preston or Ganot.

Newton's Law of Cooling.—The first attempt to enunciate a law expressing the rate of loss of heat was made by Newton. He assumed that the rate of cooling of a body in a current of air was proportional to the difference of temperature between the body and the air. This law has been found very convenient, and sufficiently accurate to be employed when the difference of temperature is not more than a few degrees, but it breaks down utterly for large differences of temperature.

Experiments of Dulong and Petit.—An elaborate investigation was made in 1817 by the above two workers, into the cooling from large thermometer bulbs. By conducting experiments both in gases and in vacuo, they were able to separate convection from radiation, and to obtain empirical formluæ for each. Their conclusions were as follows :—

For radiation $R=k(a^t-a^{t_o})$ where R is the rate of radiation, k and a are constants, and t and t_o the temperatures of the body and surrounding gas respectively. For convection

$$V=mp^c(t-t_o)^{1\cdot233},$$

where V is the velocity of cooling, m and c are constants, and p is the pressure of the gas.

The former of these two formulæ has been superseded by that of Stefan, described below ; but the second still represents almost all that is known as to convection loss. By aid of these two formulæ, Thomson was able to separate the radiation from the convection losses in the case of his hollow sphere containing boiling water, which was used as a standard of radiation in his determination of the mechanical equivalent of light, described in the last chapter. MM. Provostaye and Dessains in 1846 carried out further experiments on the lines of those of Dulong and Petit, and somewhat modified their conclusions.

Work of Melloni.—Before passing to the more recent and accurate laws of radiation, some mention must be made of the work of other experimentalists. Melloni in 1833 carried out a vast number of experiments on the transmission of radiation, and the properties of various substances, using the thermopile as receiver. His conclusions may be briefly summarized as follows—

Radiation travels in straight lines in all directions from a hot body, and is propagated in a vacuum as well as in air. Its intensity or heat received per unit area is proportional to the temperature of the source, inversely proportional to the square of the distance from it, and is smaller the greater the obliquity of the path to the radiating surface. We have already seen, however, that the proportionality of radiation to temperature only holds over a very limited range.

Melloni also demonstrated that radiant heat could be reflected and refracted, with the same laws as those of light ; and he, Leslie, and others investigated the radiating, absorbing, transmitting, and reflecting powers of

various substances. The conclusions derived were as follows :—

Black surfaces possessed the highest radiating and absorbing power. A perfectly black surface, *e.g.*, lampblack absorbed practically the whole of any radiation that fell on it. A polished metal surface only radiated or absorbed about 10 per cent (or in the case of burnished silver only 2.25 per cent) of that radiated or absorbed by a black surface. The radiating and absorbing powers of a surface were always found to be equal.

The reflecting power was found to vary from 97 to 74 per cent for various metals down to zero for lampblack.

Lastly, the transmission or diathermancy varied very much. Glass and alum only transmitted about 10 per cent of the heat falling on them, while rock-salt transmitted 92 per cent, and fluorspar under some conditions as much as 78 per cent. As a rule, however (rock-salt excepted), the proportion transmitted is smaller for radiation from low temperature sources than from those at a higher temperature.

Tyndall in 1862 greatly extended the study of absorption, especially as regards gases. But his principal advance was in the investigation of the distribution of energy in the spectrum. Using a rock-salt prism to form a spectrum, and a line thermopile, by which the intensity of radiation could be measured in a very narrow portion of it, he found that the intensity in the luminous portion of the spectrum increased on passing from the violet to the red end, and that on going still further outside the spectrum the deflection still continued to increase for some little distance, after which it rapidly fell away.* The curve of distribution of intensity was, in fact, like that in Fig. 1. It was further noticed that the position of maximum intensity varied with the source, being considerably beyond the visible spectrum with a low temperature flame, and only slightly outside it with an arc.

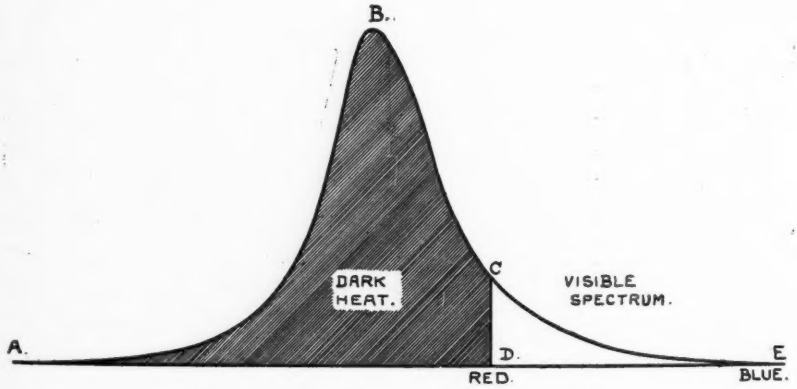


FIG. 1.—Thermal Spectrum of Electric Light.

Tyndall thus devised the spectrum integration method of determining luminous efficiency, by comparing the radiation within the spectrum with the total radiation from the source. He also devised the absorption method previously described.

* The greater intensity of heat outside the spectrum had indeed been noticed by Herschel as far back as 1800.

(To be continued.)

The Cost of Street Illumination.

By Haydn T. Harrison, M.I.E.E.

Street-illumination is more often called street-lighting, probably because it generally refers to a number of lights erected in streets, which do little more than indicate the position of the road and pavements. The making of a street or road is in most cases in the hands of the local surveyor, who more often than not treats the whole thing as his father did before him, with the exception that he uses gas or electric lamps for the lighting of his streets in place of oil; but his method of obtaining what he considers suitable lamps for this purpose is to specify not the light these lamps should give, but the quantity of gas or electrical energy they should take. The result is that thousands of streets in this country are still lighted in the same way as they were twenty years ago; whereas if a little attention were paid to the correct arrangement and candle-power of the lamps, and the number of posts necessary to each street, far better illumination would be produced at a much lower cost.

The writer was asked to advise as to the best way of improving the illumination in the streets of a small town where both gas and electricity were available for the purpose; the latter being supplied through overhead mains attached to posts erected at the side of the road at about forty yards apart. The gas company had been asked to erect the lamp which they would recommend; and—though the reader possessing some knowledge of the elementary laws of illumination, may find it difficult to believe—they erected a post and lantern containing two inverted gas mantles. This appealed to a few members of the council on account of its brilliancy, but the majority at once noticed that, with the exception of the road and pavement close to the post, the illumination resulting was very poor. If the manager of the local gas company had had the slightest knowledge of the laws governing illumination he would have known that inverted mantles were quite unsuitable for street lighting in places where the posts are low and at long distances apart, and that ordinary mantles were well adapted for the purpose, owing to the relatively high candle-power of the rays approaching the horizontal.

The electrical engineer who consulted the writer followed his advice, and hung up, between the adjacent poles supporting his mains, eight 16-candle-power 25-volt osram lamps, connected in series. These came at distances of 15 yards apart, and the cost of erection and all materials was less than that of the one gas-post and fittings: the relative cost of lighting was the same. The interesting part, therefore, was the respective results as regards illumination. It requires very little calculation to see that the minimum illumination with the electric lamps—owing to their close proximity—was as high as it is even in Oxford Street; and, with the gas, lower than it would have been if a single ordinary gas mantle had been used.

I have put forward this as an example of the effect of a little intelligent use of the laws of illumination, which in this case resulted in ten times better illumination being obtained at the same cost. But as many readers will ask what was the opinion of the council or of the man in the street, I might mention that in the future the whole town will probably now be lighted by small candle-power lamps at short distances apart.

It is quite time that the method of simply putting up so many gas lamps or electric lamps in a street at conventional distances apart was abandoned in favour of some more scientific allotment of the various forms of light

available for the purpose. The actual cost per thousand burning hours of the various types of lamps, and the candle-power to be obtained from each type, can now readily be ascertained by all surveyors or lighting committees. Therefore the type to use and the disposition of same for each individual case should not be difficult to decide, provided the matter is dealt with in a scientific or commonsense manner.

To take an example, let us suppose that various forms of lamps are obtainable at the following costs, including interest on capital charges :—

TABLE I.

Type o Lamp.	C.P. at 10° below horizontal.	Cost per annum of 4,000 hours (average).
(*a*) Electric flame arc lamp...	1,200	£20 0
(*b*) ,, ,,	800	18 0
(*c*) Electric open type arc lamp	600	18 0
(*d*) Gas high intensified lamp	600	17 0
(*e*) Electric enclosed arc lamp	400	14 0
(*f*) Gas, 2 mantle-burners ...	100	16 0
(*g*) Electric metal filament lamp	100	5 0
(*h*) Two electric metal filament lamps	100	6 0
(*i*) Gas, single mantle-burner	50	3 5
(*j*) Electric metal filament lamp	50	3 0
(*k*) Electric metal filament lamp	16 (Low voltage series)	1 0

This is a large choice, and is, of course, not always available; but it has been made as comprehensive as possible for the sake of an example, and any type not at his disposal can be struck out by the reader.

As it is now generally admitted that the minimum illumination at any part of the street is the correct factor on which to base street-lighting, it is necessary to see how many lamps of any type would be necessary to illuminate a mile of street up to a given standard, the average standards at present being as follows :—

TABLE II.

Class of Street.	Minimum Illumination.	Relative.
(*a*) Country roads	·005 c.f.	(1)
(*b*) Side streets	·01 c f.	(2)
(*c*) Main streets	·05 c.f.	(10)
(*d*) Important thoroughfares	·1 c.f.	(20)

Minimum illumination is at a point halfway between the posts, and is equal to the candle-power of the lamp divided by the slant distance squared, the slant distance being equal to the height of the lamp squared plus the distance to the centre of the post squared. This is given by the following formula :—

$$(1) \qquad i = \frac{CP}{\left(\frac{D^2}{2}\right) + H^2}$$

Where

i=Minimum illumination.
CP=Candle-power of rays approaching horizontal.
H=Height of lamp.
D=Distance between posts in feet.

But knowing the illumination and requiring to know the distance apart of the posts, the formula can be used as follows :—

$$(2) \qquad \left(\frac{D}{2}\right)^2 = \frac{CP}{i} - H^2$$

$$(3) \qquad D = 2\sqrt{\frac{CP}{i} - H^2}.$$

If the posts are erected alternately on either side of the road the number of posts for any given distance would not be represented by that distance divided by D, as D is the distance between two posts on opposite sides of the road, and is equal to a length of road represented by :—

$$(4) \qquad D = \sqrt{d^2 + a^2}.$$

Where :—

a=Width of road between the kerbs on which the posts are erected.
d=Length of kerb between each post.

Thus in order to find the number of posts to a given length of road if the posts are staggered, we have to find d as follows :—

$$(5) \qquad d = \sqrt{D^2 - a^2}.$$

Or in conjunction with the formula (2) :

$$(6) \qquad d = \sqrt{\left(2\sqrt{\frac{CP}{i} - H^2}\right)^2 - a^2}.$$

Applying this formula, for example, to a mile of street, 40 feet from kerb to kerb, to be lighted up to the standard of a main street, namely, with a minimum illumination of ·05 candle-

feet, by lamps erected 20 feet high, and giving 1200 candle-power, erected on the kerb on alternate sides, by using formula (6) we find that the distance d between each post measured along the kerb equals :—

$$d = \sqrt{(2\sqrt{\frac{1,200}{\cdot 05}} - 20^2)^2 - 40^2}.$$

$$= \sqrt{(2 \times \sqrt{24,000} - 400)^2 - 1,600}.$$

$$= 303 \text{ ft. or } 101 \text{ yards.}$$

Thus, with the posts at distances of 101 yards the number of posts per mile will be 17·6.

From the same formula we can calculate the number of posts for each of the other units of light, and the result will be found to be as follows. The cost per mile is also given by multiplying the number of posts by the cost per annum given in Table I. :—

TABLE III.

Type of Lamp.	Number of posts per mile.	Cost per annum per mile.
a (20 feet high) ...	17·6	£352
b ,, ...	21 5	387
c ,, ...	25	450
d ,, ...	25	425
e ,, ...	31	434
f (12 feet high) ...	70	350
g ,, ...	70	350
h ,, ...	70	420

As any smaller unit would work out at less than 40 feet apart, it is obvious it could not be used for a road such as the example before us, which is 40 feet wide ; but in the case of country roads, where the minimum illumination permissible is ·005 candle-feet, a very different financial result occurs, as will be seen by examination of the next table, worked out from the same formula, for a road 30 feet wide between the kerbs :—

TABLE IV.
Minimum Illumination ·005 C.F.

Type of Lamp.	Number of posts per mile.	Cost per annum (40,000 hours) per mile.
a (20 feet high) ...	5·5	£110
b ,, ...	6·6	119
c ,, ...	7·6	137
d ,, ...	7·6	130
e ,, ...	9·4	132
f (12 feet high) ...	19	95
g ,, ...	19	95
h ,, ...	19	114
i ,, ...	27	88
j ,, ...	27	81
k ,, ...	52	52

On comparing the two foregoing tables it is obvious that for wide thoroughfares where high illumination is required large units of light can be used without increasing the cost, but for roads where a low degree of illumination is permissible small units will give the required result at a much lower cost.

It will thus be seen that, provided the total costs per annum of the various sources of light are known, it is only a matter of calculation to ascertain which is the most economical to use ; but it must be borne in mind that, owing to the fact that the candle-power of lamps is defined in so many different ways—such as spherical, hemispherical, or maximum—it is necessary to obtain guarantees not of any of these ratings, but of the candle-power between the horizontal and thirty degrees below the horizontal. This includes angles over which it is essential the candle-power should be high, as these rays have to illuminate objects in the distance.

The importance of this point is well illustrated by an open type electric arc-lamp, any maker of which will guarantee 1,000 candle-power for 500 watts. The maximum candle-power obtained with a clear glass globe would probably be 1,000 at the best angle, which is 50 degrees below the horizontal. But if asked for the candle-power at an angle of ten degrees below the horizontal, a conscientious maker would probably only guarantee 500 candle-power, which is the usual figure found in practice with opalescent globes.

As regards the cost of maintenance of various sources of light, this is generally undertaken by the department supplying the gas or electricity, and it will be found that where there is competition the sums estimated by the competitors are as low as they can possibly be ; but this cost will obviously be much affected by local conditions and the length of the contract. For instance, if a contract is entered into of such duration that it would pay the electricity undertaking to lay a special street lighting network of mains—thus saving the cost of lamp-lighters' wages

—a considerable saving would be effected, and a low tender could be submitted. On the other hand, councils do not like entering into lengthy contracts, as improvements may come about by which they could obtain better illumination at a lower rate. Therefore the type of contract in which the consumption of gas or electricity per lantern is specified is found most satisfactory, provided a clause is inserted by which the supply undertaking agrees to periodically replace such lamps, if called upon, for any improved types which may be brought out, the cost of such replacements to be borne by the local authority.

In conclusion, it cannot be too strongly emphasized that all contracts relating to street lighting should insist upon the degree of illumination specified being maintained and, if possible, a heavy penalty be charged if the illumination is allowed to fall below the limit. It is true that this involves periodic testing by the surveyor or his assistant, but as illumination photometers for use in the street can now be obtained at a reasonable sum, and these instruments, after a little practice, can be relied upon to give accurate results within 5 per cent, no surveyor's department should hesitate to undertake this work.

A Deputation to Study Continental Street Lighting.

In a previous number attention was drawn to the action of the Boston Finance Commission in sending experts connected with gas and electric lighting to Europe to study the existing methods of lighting before deciding on a method of illumination for their own city.

It is therefore interesting to observe that at a meeting of the City of London Corporation on Thursday, Oct. 22nd, it was proposed to appoint a deputation for a similar purpose, the estimated cost being 200*l*.

Some of those present were disinclined even to spend this sum; but it was pointed out by others that thousands of pounds of the ratepayers' money might eventually be saved in this way. At the present moment the Committee were actually not in a position to decide what was the best existing method of lighting, and until this matter was thrashed out, the same uncertainty would prevail.

Ultimately the Committee's recommendation was accepted by a large majority.

Cantor Lectures on Illumination.

A series of four Cantor Lectures, dealing with the latest developments of the different illuminants, and the science and art of illuminating engineering, will be delivered before the Royal Society of Arts (St. John's Street, Adelphi) early next year by Mr. Leon Gaster, editor of *The Illuminating Engineer;* the dates at present determined upon are Feb. 15th, Feb. 22nd, March 1st, and March 8th respectively.

The Illumination of Lighthouses, Buoys, and Beacons by Means of Acetylene.

By an Engineering Correspondent.

The opening of the twentieth century was signalized by a marked progress in the existing methods of illuminating the various signals used in navigation. Acetylene enables certain advantageous conditions to be realized; it reduces the amount of personal attention that is necessary, and provides a brilliant light capable of piercing even the densest fogs.

The conditions of illumination in lighthouses, beacons, and buoys are very different. A lighthouse, as usually constituted, entails an optical projecting system embedded in masonry and mounted in a suitable tower. A beacon is usually an erection supported from below and carrying a suitable light which may be also provided with a lantern or projector; beacons are usually employed in shallow waters. Buoys, on the other hand, consist of floating bodies, and are not supported.

From the point of view of acetylene lighting we are mainly concerned with buoys and beacons; lighthouses are usually sufficiently important and complicated to require the presence of a keeper, and in such a case the advantages of acetylene-lighting, that render it particularly convenient in the case of buoys and beacons, do not weigh so heavily.

The use of acetylene results in a very bright flame, without the intermediary of fragile mantles. There is also the convenience of being able to enclose a large stock of illuminating material in a very small space. We may accomplish this by the use of dissolved acetylene, or by employing generators direct. Each of these methods has certain merits of its own.

Acetylene generators, like dissolved acetylene, may profitably be used in the case of lighthouses or very large buoys, which can be easily visited. The first lighthouse in France to be illuminated by acetylene was that at Chassiron, situated in the northern portion of the island of Oleron. This was originally lighted by petroleum, and a light of 70,000 bougies was obtained. This value was subsequently doubled by replacing petroleum by oil-gas, and again quadrupled when acetylene was installed.

To-day the illumination of this lighthouse is provided for by a group of

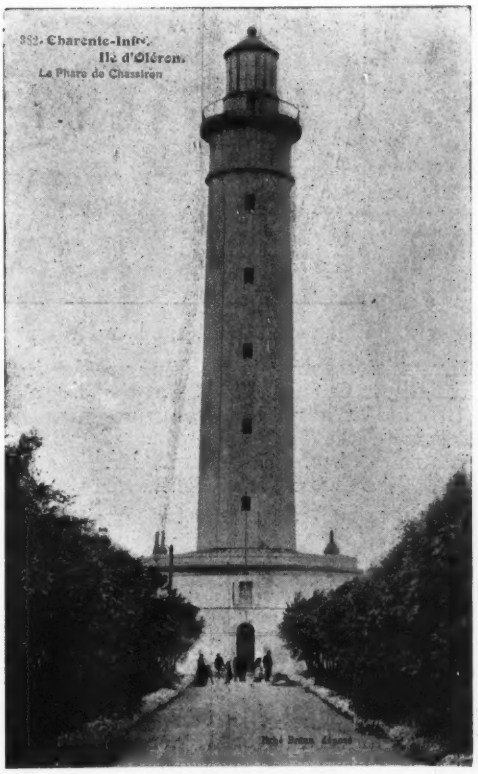


Fig. 1.—Chassiron Lighthouse.

generators and two gasometers feeding a "Sirius" burner, which consumes about 570 litres (approximately 20 cubic feet) per hour, corresponding to 2 kilograms of carbide, at a pressure of 1·25 m. During the long nights of winter the carbide consumed may amount to 30 kilos. The burner, equipped with an incandescent mantle 55 millimeters long yields 2130 bougies for 568 litres of gas, and therefore consumes roughly 0·27 litres per bougie (approximatly 105 candle-power per cubic foot).

Acetylene has been utilized for the illumination of buoys, mainly in the United States and in Canada. The first experiments were carried out in the United States in 1902, but the purity of gas consumed removed this weakness.

Two main systems of acetylene illumination for buoys have hitherto been in use: (1) those using compressed acetylene, and (2) buoys using automatic generation. The second of these two systems has been generally considered preferable partly because less space is occupied, and also because it is often an advantage not to encumber buoys with much material, when they are easily accessible and can therefore be readily recharged. Moreover, a buoy that is only capable of containing 71 cubic metres of compressed acetylene, may contain as much as 280 cubic metres in the form of carbide if operated on the automatic system. In Canada,

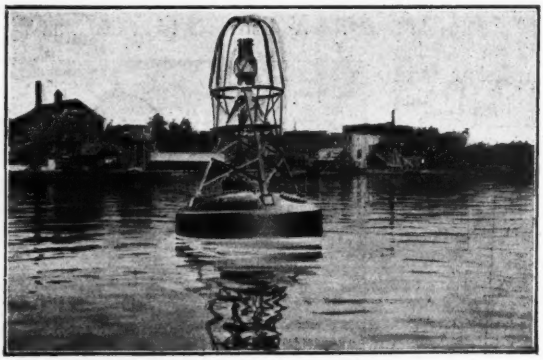


FIG. 2.—Buoy, lighted by Acetylene, on the St. Lawrence.

matter was subsequently taken up extensively in Canada in 1904, and the United States dispatched a representative to that country to report upon the system. As a result Mr. Fraser, of the United States Lighthouse Department advocates the use of acetylene on buoys.

Previous to the adoption of acetylene, he states, the buoys, lighted by gas, yielded but a feeble light, and were scarcely visible during fogs. Now, however, that acetylene has been introduced, the light is clearly distinguishable under all conditions.

There were, however, certain initial difficulties to be overcome. For instance, the burners were inclined to smoke, but greater attention to the for instance, buoys so equipped will last throughout the season of navigation without recharging.

The value of acetylene for buoys has been particularly recognized in Canada, because of the inconvenience previously experienced in continually recharging those illuminated by oil-gas, and in being obliged to maintain apparatus for compression in the neighbourhood. Under these conditions lighting by oil-gas is only tolerable when applied to a number of buoys collected together in the same locality, so that the same compressing apparatus was available for all. However, this condition can rarely be complied with, and therefore it was proposed to use acetylene, the apparatus for compress-

ing which could be installed on a small vessel. More recently, however, this system has largely given place to the use of automatic generating buoys.

Such buoys have been very much used in America, on the great rivers. In Europe, however, and notably in Sweden, where maritime illumination is of the greatest consequence, dissolved acetylene has been mainly employed.

Sweden, for instance, possesses a very fine system, involving the use of tubes of dissolved acetylene, having a capacity of about 50 litres. The flashing beacons distributed on the coast and equipped in this way, are able to act for seventy days in succession without it being necessary to attend to them. These results, however, have only been achieved by the use of an automatic apparatus enabling the beacons to be automatically lighted up when night falls, and, similarly, the supply of acetylene to be cut off at sunrise. For this purpose the special "Daten" arrangement of the Aktiebolaget Gas Accumulator Co. The working of the apparatus is based upon the action of two surfaces, one of which is black, and absorbs solar radiation, while the other reflects it. This gives rise to a difference in temperature of the two surfaces, and consequently an unequal expansion. During the day, therefore, the surfaces expand differently,

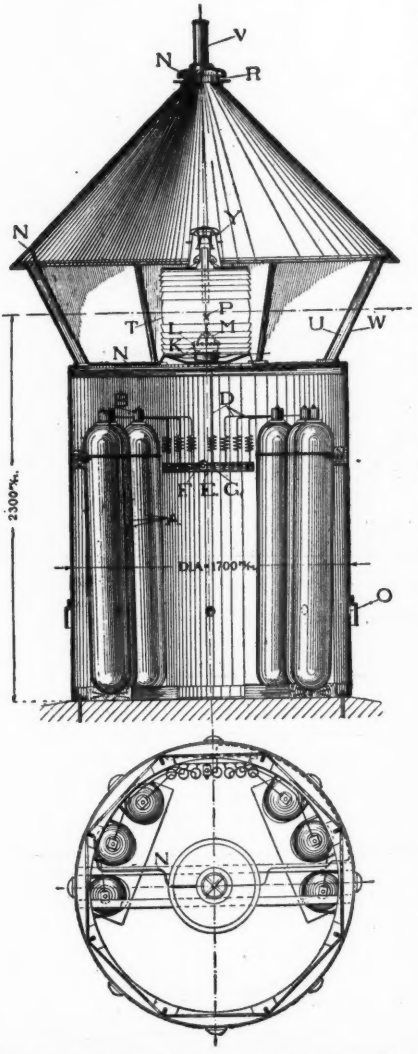


FIG. 3.—Complete Lighthouse Installation, with lantern, with store of 6 tubes of dissolved acetylene, each of 5,000 litres capacity, operated on "Eclipse" system by solar heat valve.

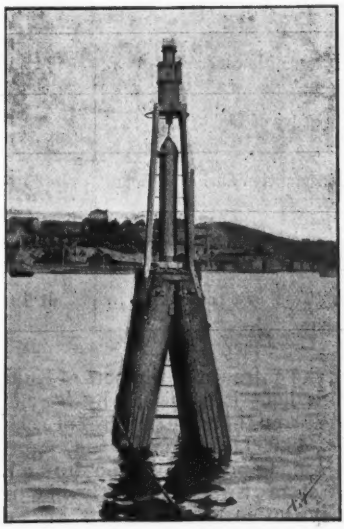


FIG. 4.—Lantern at Goteborg, equipped with one tube of dissolved Acetylene, 5,000 litres capacity. Requires recharging every two months.

and thus causes a valve to close. During the night, on the other hand, the effect does not take place, and the valve remains open.

With this apparatus ordinary steatite burners consuming 15, 20, or 25 litres per hour are employed, in place of the older type, consuming 12 litres per hour only; they are fed direct from the cylinders of dissolved acetylene.

Burners consuming 25 litres per hour. and run on a flashing system entailing alternate periods of 0·3 seconds brightness and 2 seconds of obscurity, only utilize about 70 litres of acetylene during a complete day. Consequently a tube of dissolved acetylene of 50 litres capacity, which will yield roughly 5,000 litres of acetylene, would serve to supply a 25 litre burner for about 70 days of 24 hours; if 12 litre burners, consuming about 46 litres per day in all, are used, a single tube will last for 108 days.

The costs for the different sizes of burners work out roughly as in Table I.

The first lighthouse lighted on the system just described is at Gasfeter at the entrance of the port of Kanneby. This light is furnished by 9 cylinders, each containing 5,000 litres of acetylene *i.e.*, 45,000 litres in all.

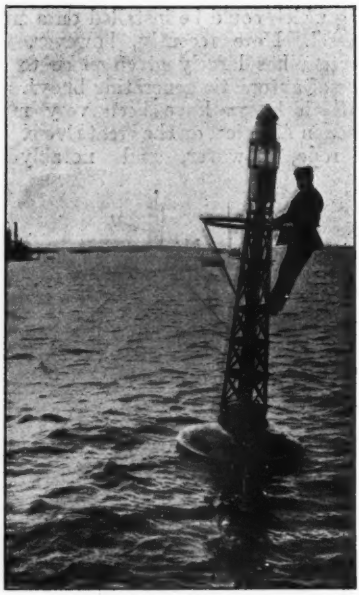


FIG. 5.—Illuminated Beacon, worked on eclipse-system, and capable of supplying light without recharging for one year.

TABLE I.

Nature of burner	15 litres	20 litres	25 litres
Intensity of Light	170 bougies	260 bougies	360 bougies
Consumption during 24 hours	46 litres	58 litres	70 litres
Consumption during 330 days	15,200 litres	19,200 litres	23,100 litres
Total cost per annum ...	61·5 francs	77·75 francs	80·85 francs

Among other lighthouses on the coast of Sweden similarly illuminated may be mentioned those at Vexley, Fors Halla, Fjordskar, and Bramskar. Numerous lightships, beacons, and buoys of all descriptions lining the coast employ the same system.

Dissolved acetylene is also used for maritime purposes by Norway, Russia, Finland, Denmark, Holland, and the Argentine Republic. It is also understood that the Austrian authorities are considering the utilization of the system in the Adriatic.

R. G.

Notes on the Manchester Electrical Exhibition.

By an Engineering Correspondent.

October will long be remembered by all engaged in the various branches of the electrical engineering industry for at least three important events that took place during that month. Two of these, *i.e.*, the Conference on Electrical Units and Standards and the meetings of the Electro-Technical Commission, were of international interest, and their achievement in establishing a plain and intelligible medium of communication between the electrical manufacturer and the consumer, and in settling the terminology of electrical units, possesses a world-wide importance. The other event—the Manchester Electrical Exhibition—was not so universal in its claim upon the attention of scientific men and engineers as were the two events previously named. But its importance in this country cannot be questioned.

The twofold purpose of the Electrical Exhibition was to demonstrate the progress which had been made in the practical applications of electrical science, and to provide the fresh novelty and interest that are occasionally necessary for the encouragement of a trade revival. It may safely be said that never before in this country has the technical advance of any industry been so unmistakably demonstrated as has been that of the electrical industry by the Manchester Exhibition.

From the point of view of the illuminating engineer the exhibition deserved respectful attention on account of its being the first in which matters affecting illumination were so much in evidence. The display of electrical apparatus employed in almost every branch of illuminating engineering was exceedingly comprehensive, and showed that it is quite possible to harmonize adequate and efficient lighting with artistic effect.

A striking illustration of really effective artistic lighting, and of harmonization between the illumination and the general scheme of decoration of an interior, was to be had in the model house furnished by Messrs. Goodall, Lamb & Heighway, of Manchester. The painted ceilings and daintily tinted walls of the various rooms were shown to the best possible advantage under the nature of the illumination employed to display them.

In the spacious drawing-room a crystal electrolier and wall fittings shed an even light on furniture of quaint design, and showed to advantage the panelled walls painted in delicate tones of soft greens with enriched white mouldings surrounding them, and a ceiling painted in the harmonious tints of an evening sky. Messrs. Drake & Gorham were responsible for the lighting installation throughout the house and for all the fittings. All the energy required was obtained from a small petrol engine driving a dynamo and operating in conjunction with a battery of accumulators.

Before dealing with the illuminating apparatus displayed for utilizing electricity, it may be as well to say a word about the general illumination of the exhibition. The approaches were lighted by flame arc lamps and the road frontage was festooned with Robertson incandescent lamps. The interior of the building was illuminated by 28 "Oriflamme" arc lamps of the magazine pattern, each having a burning life of from 36 to 40 hours with each trim, and the magazines holding from six to nine pairs of carbons.

The Union Electric Co., Ltd., fitted eight "Excello" arcs in the roof of their stand. Four of these were burning on a direct current circuit, and four on an alternating current circuit, the object of this arrangement being to show that the "Excello" alternating current arc is equally as good as the

"Excello" direct current. Two sets of lamps were also suspended from the roof for shadowless illumination.

The General Electric Co., Ltd., showed the "Angold" flame arc-lamp, which attracted an amount of attention on account of its long burning life, and the "Flamgold" gravity feed arc-lamp, 1908 pattern, in which the most noteworthy improvements were the evenness of burning and absence of strain on the lamp mechanism. The "Jandus" regenerative flame arc-lamp, which is simple in construction, and has an effective life of 70 hours with one pair of carbons, was exhibited by Messrs. Drake & Gorham, Ltd. "Victor" arc-lamps were exhibited by the Electric and Ordnance Accessories Co., Ltd., in three types, viz., standard enclosed, having only one moving part, and made for d.c. circuits only; miniature enclosed arcs; and d.c. flame arcs.

The Gilbert Arc Lamp Co., Ltd., exhibited long burning flame lamps of street lighting, interior lighting types, and multiple carbon and enclosed lamps, while Messrs. Siemens Bros. Dynamo Works Co. also showed a number of arc lamps of various types. Messrs. J. & H. Grevener displayed their "Arco" flame lamp for d.c. and a.c. circuits.

The exhibits of incandescent lamps included many metallic filament lamps which are appearing this season for the first time, and all the well-known types were to be seen.

Messrs. Siemens Bros. Dynamo Works Co. had a show case of tantalum lamps and parts of the lamp illustrating the process of manufacture, and the tantalum lamp and holophane shade were to be seen on many other stands in the exhibition.

The General Electric Co., Ltd., showed a fine arrangement of osram lamps for high and low voltages. The "Metafil" of Messrs. The Edison & Swan United Electric Light Co., Ltd., practically made its début to the public. This lamp is manufactured in sizes suitable for most of the standard voltages. Messrs. G. M. Boddy & Co. exhibited the "Metalik" metallic filament lamp arranged to show tests for life and efficiency. The filament of this lamp is supported at the bottom, the loop being insulated by means of a special chemical process, which renders the filament very rigid, and enables the lamps to be run in any position.

The "Sunbeam" metal (tungsten) lamps from 25 volts up to 250 volts, and of various candle powers up to 100 c.p. were also exhibited. The Sunbeam Lamp Co. claim for these lamps an efficiency of 1¼ watts per c.-p., and immunity from breakage in transit, owing to the shortness of the bulb. Messrs. Falk Stadelmann & Co., Ltd., exhibited their "Sirius - Effesca" tungsten metallic filament lamps with artistic fittings illustrating their application, while the International Electric Co., Ltd., showed the "Orieco" metallic filament lamp. A wide range of carbon filament lamps was displayed, the Robertson Electric Lamp Co., Ltd., having an electric lamp making exhibit which closely resembled their display at Olympia.

The exhibits of fittings were chiefly confined to the latest designs suitable for residential use, examples being shown of the Adams, Sheraton, Louis XVI., Flemish, &c., schools. Nearly all the fittings shown were tasteful in conception, well finished, thoroughly modern. Two or three types of convertible fittings were shown, suitable for use in small houses, where the dining room is usually used as a drawing room, and the fittings exhibited were easily convertible for use in either case.

The show of meters and instruments formed a notable feature of the exhibition, many of the leading firms showing measuring instruments of quite modern design.

Among the special instruments exhibited was a 15 amp. time meter, suitable for purposes where current is charged by the time of consumption, such as, for instance, on arc lamp circuits where the central supply authority may be charged an inclusive figure to represent the cost of current, consumption of current, and the necessary amount of trimming.

Photometric apparatus was not shown to any great extent, but on the stand of Messrs. Siemens Bros. & Co.,

Ltd., were to be seen some interesting types. The new Siemens collapsible photometer, which was exhibited provides a very suitable instrument for measuring the efficiency of various lamps and permits making such measurements in the simplest and most convenient manner without a dark room, and with an accuracy sufficient for all practical requirements.

The measuring system is based on the angle mirror method. The apparatus consists essentially of three boxes connected together by collapsible bellows. The middle part of the apparatus contains a voltmeter and an ammeter; the photometer screen and two collapsible rails screwed on to the top are engraved with millimetre and candle-power scales. The instruments are connected to the circuit in such a manner that they indicate only the current and the pressure flowing through, and at the lamp terminals respectively, so that the actual watt consumption of the lamp is measured.

The Bunsen photometric disc is employed, but the usual grease spot is replaced by a silver spot between the two plates of matt glass. The two other parts of the apparatus each contain two mirrors inclined at an angle of 120 deg. to one another, the standard lamp being in one part and the lamp to be tested in the other. The lamps hang vertically so that the apparatus is suitable for testing lamps which can only burn in this position. Tests can be made in full daylight. As the standard lamp and the lamp to be tested are connected in parallel and the former is in series with a resistance equal to the resistance of the ammeter in the circuit of the other lamp, both lamps have practically the same difference of potential at their terminals and can, therefore, readily be compared with one another.

In order to be able to determine candle-power in cases where the supply pressure is higher or lower than the rated pressure of the lamps, the standard lamp can be fixed at a different distance from the screen, so that the same amount of illumination is produced on the screen as at the rated voltage.

On the stand of Messrs. Venner & Co. were shown some interesting meters by Messrs. Chamberlain & Hookham, Ltd. The watt-hour meter attracted considerable attention; this type of meter having no brushes or commutator, and being unaffected by stray magnetic fields. Other types of interest were the slot electrolytic, cash register, and two-rate meters. The electrolytic meter shown was of the shunted type; only one fifty-thousandth of the current passing through the electrolyte of dilute sulphuric acid, which, together with the platinum electrodes was sealed up in a glass vessel. The two-rate meter exhibited was of the Hookham type, contained in the same size case, but fitted with a counting train, having two sets of dials, the upper registering the consumption during the high-rate period, and the lower the low-rate period, the change from lower to upper dial being effected by a time switch closing the circuit of a solenoid connected across the mains. Venner time switches were also much in evidence, some of the patterns exhibited being extremely ingenious.

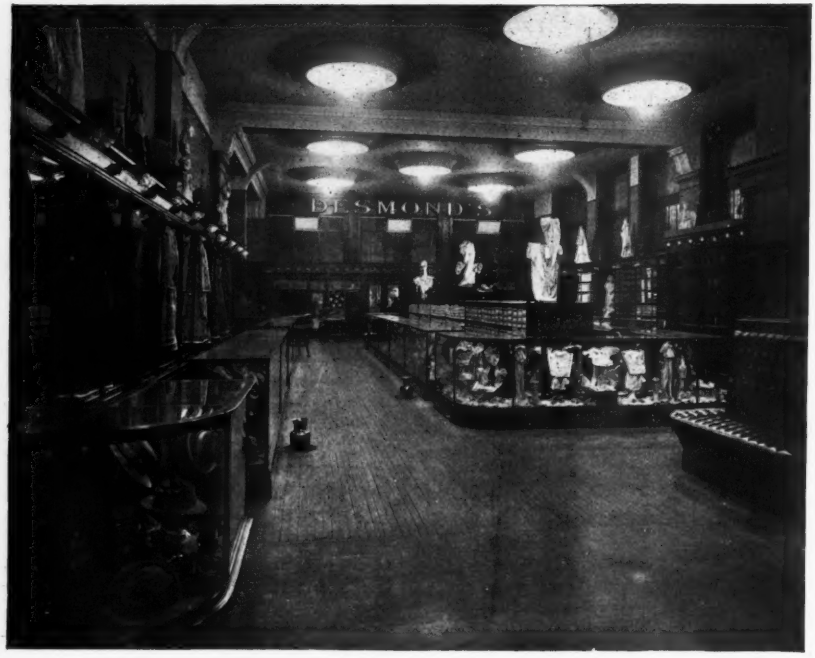
A comprehensive collection of electrical instruments was on view on the stand of Messrs. Elliott Bros., a large number being shown under actual working condition with switchgear manufactured by Messrs. Eckstein, Heap & Co., in conjunction with whom Messrs. Elliott Bros. exhibited. The exhibit included ammeters, voltmeters, leakage indicators, testing sets, telegraph apparatus, &c. A feature of interest was the "Harrison" Universal Photometer. This consists of an instrument to measure the illumination derived from, or the candle-power of, a lamp of any nature under a large variety of conditions. The chief novelty of this instrument lies in the fact that it embodies a flicker disc, somewhat of the Whitman pattern, but rotated by a blast of air under the control of the operator.

Enclosed Arc-Lamps for Interior Shop-Lighting.

THE illustration shows an interesting example of interior illumination of a shop in Los Angeles, California, recently described by Mr. C. H. Stickney, by means of enclosed arc lamps mounted in a concentric diffusing reflector.

The method is specially applicable in cases in which the ceiling is high, and an even, diffused illumination is desired—a "spotty," uneven illumination being particularly undesirable for shops of this kind. The ceiling was in this case about 16 ft. high, and the floor area about 14,000 square ft.

It is claimed that this method is also specially applicable to shops devoted to the sale of clothing, because of the correct colour-definition afforded by enclosed arcs. The use of the reflectors also facilitates the production of a "soft" illumination coupled with an absence of sharp shadows. It is also stated that the annual cost of upkeep is exceedingly low. It will, however, be interesting to observe how enclosed arc-lamps of this type compare with high candle-power osram lamps, for which similar claims as regards colour and cheapness have been put forward (see *Illuminating Engineer*, October, p. 861).



Interior lighting, by enclosed arcs, of a clothing store, Los Angeles, California.

SPECIAL SECTION.

The Second Annual Convention of the Illuminating Engineering Society.

THE second annual meeting of the Illuminating Engineering Society took place in Philadelphia on October 5th and 6th. The proceedings seem to have been characteristic of the vigour and enterprise of this body, and successful in every way. The membership of the society, since its inauguration nearly three years ago, has grown to over a thousand, and it is significant that over a quarter of the members enrolled were able to attend the convention, though in many cases this undoubtedly entailed making journeys of considerable length.

As an indication of the value of the work that is now being carried out, it is only necessary to point to the very varied and valuable collection of papers read on this occasion, a list of which will be found on the next page. Although we are devoting exceptional space to this important collection, it is naturally impossible to print even adequate extracts of all in this one number. We are, however, in a position to reproduce a few, selected so as to indicate the extent of the ground covered. We hope to deal with others in a subsequent number, and also to give some account of the discussion which followed.

Those papers which we at present deal with, however, by themselves serve to emphasize the scope of the work of the society. Among them we include a paper dealing very exhaustively with a practical illuminating engineering design by Mr. Marks, contributions dealing with the standpoints of the architect and the physiologist respectively, a paper on oil-lamps, and a paper dealing with daylight-illumination, and describing a number of original researches. At the present moment, too, when the question of an international standard of light is under discussion, the report presented by Dr. A. H. Humphreys, embodying as it does a record of valuable co-operation between those representing gas and electric lighting and illuminating engineering, is of special interest.

We also hope to deal in greater detail in our next number with Dr. Louis Bell's Presidential Address. Dr. Bell, who has recently been touring the chief cities of Europe with the object of studying different developments of street-lighting, naturally dealt largely with this subject. His remarks, coming from one who is familiar with the conditions on both sides of the Atlantic, are therefore of particular interest at the present moment, when the question of street-lighting is the subject of a considerable amount of discussion in Europe.

As Dr. Bell points out, the present conditions of civilization have called into play an entirely different set of conditions from those existing but a few generations ago. More and more business is now being transacted by night, and we can no longer be satisfied with installations merely intended to satisfy temporary and immediate needs. We now require permanent adequate illumination, and the exact intensity and location of the sources, &c., calls for a thorough and systematic study.

Dr. Bell seems to have found something to criticize in American methods, and to have expressed his belief in the method of measuring street-illumination on a horizontal plane. He likewise condemns the present "moonlight schedule," according to which an allowance is made for the order of illumination which the moon is believed to furnish, if unobscured. It is to be noted that

SECOND ANNUAL CONVENTION

OF THE

ILLUMINATING ENGINEERING SOCIETY

HELD IN

Philadelphia, October 5th and 6th, 1908.

PROGRAMME OF PAPERS.

MONDAY, OCTOBER 5th, 10.30 A.M. MORNING SESSION.

ADDRESS OF WELCOME. By Hon. John E. Reyburn, *Mayor of Philadelphia.*

1. PRESIDENTIAL ADDRESS. By Dr. Louis Bell.
A study of the problem of street-lighting in its broader aspects, especially with reference to the choice and placing of lamps in their relation to effective illumination.

2. REPORT OF COMMITTEE ON NOMENCLATURE AND STANDARDS. By Dr. A. C. Humphreys, *President Stevens Institute.*
An account of the conferences of committees of the Illuminating Engineering Society, the American Institute of Electrical Engineers, and the American Gas Institute on the subject of a National Candle Unit, which unit has been formally accepted by the two first-mentioned bodies, and will come up for action in October at the annual convention of the American Gas Institute.

MONDAY, OCTOBER 5th, 8 P.M. EVENING SESSION.

3. MODERN GAS-LIGHTING CONVENIENCES. By Mr. T. J. Litle, Jr.
Describes the various methods of gas-lighting ignition by electrical means, pilot flames, &c., with an account of some other special gas-lighting fittings and of a small candle-power gas unit.

4. ILLUMINATING VALUE OF PETROLEUM OILS. By Dr. A. H. Elliott.
An account of a number of experiments showing the value of petroleum oils as constant sources of light of great reliability, with data of experiments with oils of various densities used in a variety of commercial types of lamps.

5. STREET-LIGHTING FIXTURES: GAS AND ELECTRIC. By Mr. H. Thurston Owens.
Street-lighting is divided into five classes, and the methods discussed for securing the best illumination for each class.

6. STRUCTURAL DIFFICULTIES IN INSTALLATION WORK. By Mr. James R. Strong.
Advocates the laying out of outlets for an office building on the basis not of separate offices, but of each floor as a whole; and for residences on the basis of the darkest probable decoration of rooms, with outlets so located as to admit of any probable changes in arrangement of furniture.

7. ARCHITECTURE AND ILLUMINATION. By Mr. Emile G. Perrot.
The subject is treated under the heads of 'Necessary Illumination or Lighting" and 'Decorative Lighting,' with reference to an example of each case.

TUESDAY, OCTOBER 6th, 9.30 A.M. MORNING SESSION.

8. INTENSITY OF NATURAL ILLUMINATION THROUGHOUT THE DAY. By MR. LEONARD J. LEWINSON.
Gives the result of measurements of illumination from the sun and the moon, the determinations covering the entire range of the twenty-four-hour period and different conditions of weather.

9. THE INTEGRATING SPHERE IN INDUSTRIAL PHOTOMETRY. By DR. CLAYTON H. SHARP and MR. PRESTON S. MILLAR.
Treats of the theory of the integrating sphere and gives experimental data on the test and performance of large and small spheres in the photometry of arc and incandescent lamps.

10. THE IVES COLORIMETER IN ILLUMINATING ENGINEERING. By DR. HERBERT E. IVES.
Describes an instrument for the measurement of all kinds of light in terms of the three primary spectral colours, with a table of readings for all the various sources of illumination.

11. CALCULATING AND COMPARING LIGHTS FROM VARIOUS SOURCES. By MR. CARL HERING.
The physical meaning of the various quantities involved by lighting calculations and the laws applying to them are explained, the formulas put in shape for direct practical application, with numerical examples to illustrate their use in calculating and comparing light from different kinds of sources.

12. THE CALCULATION OF ILLUMINATION BY THE FLUX OF LIGHT METHOD. By MR. J. R. CRAVATH and MR. V. R. LANSINGH.
Practical application of a method suggested by Dr. Clayton H. Sharp whereby the total flux of light is calculated in lumens, and the average illumination of a given plane determined from the number of lumens falling on that plane.

TUESDAY, OCTOBER 6th, 2 P.M. AFTERNOON SESSION.

13. STREET-LIGHTING WITH GAS IN EUROPE. By MR. E. N. WRIGHTINGTON.
Describes the various methods of street-lighting with gas employed in London, Paris, Berlin, Vienna, &c.

14. DESIGN OF THE ILLUMINATION OF THE NEW YORK CITY CARNEGIE LIBRARIES. By MR. L. B. MARKS.
A preliminary paper treating of the lighting problems involved in the design of the illumination of public libraries, and including details of the design of the illumination of the Carnegie libraries in New York City.

15. ENGINEERING PROBLEMS IN ILLUMINATION. By MR. ALFRED A. WOHLAUER.
A number of engineering problems in illumination are presented and their solution indicated.

16. INTRINSIC BRIGHTNESS OF LIGHTING SOURCES. By MR. J. E. WOODWELL.
Treats of the intrinsic brightness of lighting sources from the hygienic standpoint, and discusses the practical application of this factor in the design of illumination.

17. SOME EXPERIMENTS ON REFLECTION FROM CEILING, WALLS, AND FLOOR. By MR. V. R. LANSINGH and MR. T. W. ROLPH.
An analysis of the effect of reflected light from ceiling, walls, and floor—separately and in various combinations—upon the intensity and uniformity of illumination, the analysis being based upon illumination tests of a room equipped with the eight possible combinations of light and dark ceiling, walls, and floor.

18. THE RELATION BETWEEN CANDLE-POWER AND VOLTAGE OF DIFFERENT TYPES OF INCANDESCENT LAMPS. By MR. FRANCIS E. CADY.
The paper establishes that the exponent expressing the rate of change of candle-power with change of voltage is not a constant, but a function of the watts per candle; that this exponent is different for different types of filaments, and that its value decreases as the watts per candle decrease.

Mr. Lewinson, in his paper dealing with daylight-illumination, comments upon the same subject.

Dr. Bell also pleads for consideration of the exact use for which certain streets are intended, and criticizes the attempt of some American cities to illuminate the whole town-area with uniform intensity, irrespective of which streets are most important. He considers that the illumination in a main thoroughfare should suffice to enable a pedestrian to read ordinary print with comfort.

Another paper with which we hope to deal subsequently is that by Dr. Clayton Sharp and Mr. Preston S. Millar on the use of the integrating sphere. This paper consists of a well-illustrated description of the practical working and advantages of the globe, which should be of great interest after the recent articles in our columns on the subject; it is also satisfactory to observe that the study of the use of this globe, which has received so much attention in Germany, is now being taken up in the United States.

Hitherto the integrating globe has been mainly employed in the determination of the mean spherical candle-power of large sources, arc-lights, and the like. The authors, however, comment upon its value for the same purpose in connexion with the photometry of glow-lamps, the flicker and other inconvenient results of the rotating method being avoided.

Among other papers with which we have still to deal we may mention that of Mr. Ives, who describes a form of instrument for comparing the colour-values of various illuminants. The paper by Mr. Karl Hering is a useful compilation of the various symbols and formulæ used in illuminating engineering. Two papers by Messrs. Cravath and Lansingh and Lansingh and Rolph deal with the calculation and use of the conception of flux of light in illuminating engineering, and the effects of reflection from various types of walls and ceilings respectively. Mr. A. A. Wohlauer discusses a series of practical problems in illumination, including the study of methods of producing a uniform illumination and the design of reflectors to serve this end.

A very important practcal aspect is touched by Mr. J. R. Strong, who discusses the placing of outlets in an office-building and methods of arranging them so as to provide for possible alterations in the disposition of the furniture. The whole subject of illuminating engineering is intimately bound up with the positions of outlets and sources, and papers on this subject are much to be desired.

We have also to mention a contribution by Mr. H. Thurston Owens on 'Street-Lighting Fixtures,' and another by Mr. T. J. Litle, Jun., dealing with modern gas-lighting conveniences, with special reference to electrical ignition.

It is interesting to observe that the first autumn meeting of the New York section of the Illuminating Engineering Society was arranged for the 15th of last month, and was devoted to a review of the various papers presented at the Convention. Certainly they provide ample food for discussion.

The New Physical Laboratory of the National Electric Lamp Association, U.S.A.

A RESEARCH laboratory has been organized by the National Electric Lamp Association for the purpose of undertaking physical and chemical investigations into problems relating to electric lamp manufacture, &c.

The laboratory is to be placed under the direction of Dr. E. P. Hyde, formerly of the National Bureau of Standards. Dr. Hyde's connexion with the laboratory augurs well for the valuable work which will doubtless be undertaken.

Report of Committee on Nomenclature and Standards.

By Dr. A. C. Humphreys.

(Paper read at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1908.)

The Committee on Nomenclature and Standards, while not ready to make a final report, reports the progress already made in the direction of establishing a common national and international unit of candle-power.

The special work referred to was assigned to a sub-committee, and the report of this sub-committee, through its secretary, Dr. E. P. Hyde, will best serve to indicate the progress already made, and is as follows :—

REPORT OF SUB-COMMITTEE ON NOMENCLATURE AND STANDARDS OF THE ILLUMINATING ENGINEERING SOCIETY.

At the first annual convention of the Illuminating Engineering Society held in Boston, July 30th–31st, 1907, the question of a possible agreement upon a common national and international unit of candle-power was presented* for consideration. As a result of the interest in this subject manifested by the members of the society in the discussion which followed the reading of the paper, the question was further presented for consideration at a meeting of the American members of the Committee on Nomenclature and Standards, which was held in Boston July 30, 1907, during the convention. At this meeting the following resolution was unanimously adopted :

Resolved :—" That a sub-committee on nomenclature and standards be appointed by the Chairman to confer with similar committees of the American Institute of Electrical Engineers and the American Gas Institute, with a view to the consideration of the adoption of a unit of light, and with the request that it report to the main committee at the earliest possible date."

In accordance with this resolution the Chairman appointed the following as members of the sub-committee on Nomenclature and Standards : Dr. Louis Bell, Mr. J. B. Klumpp, Dr. C. H. Sharp, and Dr. E. P. Hyde. The sub-committee held a meeting in New York on September 20th, at which Dr. Bell and Dr. Hyde were elected chairman and secretary respectively, and plans were made for interesting the American Institute of Electrical Engineers and the American Gas Institute in the movement for a common national and international unit of candle-power. To this end the following communication was drawn up and presented to the American Gas Institute at its annual convention held at Washington, October 16th–18th, 1907.

Walton Clark, *President.*

Dear Sir : About one year ago, the Illuminating Engineering Society created a committee, representing the varied interests in this country and abroad, to consider the question of establishing suitable, and, if possible, universal nomenclature and standards for the science of illuminating engineering.

The question of a common national and international unit of candle-power was taken into consideration by the American members of this International Committee, and upon motion, Dr. A. C. Humphreys, the chairman of this committee, appointed a sub-committee to confer with similar committees from the American Gas Institute and the American Institute of Electrical Engineers.

As a result of numerous recent investigations it has been established that the value of the candle unit defined as 1/10 of the intensity of the Harcourt 10 candle-power pentane lamp is different from that obtained through the Hefner, by the use of the ratio, one Hefner candle= 0·88 British Parliamentary candle. The amount of the difference is not definitely known, but is probably about 4 per cent, the unit obtained through the Harcourt 10 candle power pentane lamp being

* Primary, secondary and working standards of Light ; *Transactions* Illuminating Engineering Society, Vol. 2, No. 7, pp. 426-439 ; October, 1907. See also *The Illuminating Engineer*, (London), January and March, 1908.

smaller. Whether this difference is due to a change in the value of either of the two units (the candle unit in England or the Hefner unit in Germany), or whether it is due to errors in the earlier comparisons between the two units which gave the ratio of 0·88 is immaterial for our present purpose. The important fact which we desire to present for your consideration is that although in the photometry of both gas and electric lamps in the United States the unit has nominally been the British Parliamentary candle, it has been obtained in different ways in the two industries.

In the photometry of gas the English example has been followed, and the candle unit in use in this country is probably not very different from that in use in England. On the other hand, the unit used in the photometry of electric lamps, following the recommendation of the American Institute of Electrical Engineers, has been obtained through the Hefner by the use of the ratio, one Hefner candle = 0·88 British Parliamentary candle. We are, therefore, confronted at present with the existence of two different units of candle-power in the United States, differing from each other by about 4 per cent. It is evident that such a condition is not only unfortunate but extremely disadvantageous to the better interests of either industry, and any action that would tend to bring the two units into agreement should be welcomed by all concerned, provided such action does not work hardship upon any of the interests involved.

With the establishment of State commissions for gas and electricity, which will look more and more to the Federal Bureau of Standards for standards of candle-power, complications will certainly result if the unit recognized in any industry is not in agreement with that maintained at the Bureau of Standards and it is obviously impossible for the Federal government to maintain and legalize two different units for use in the photometry of gas and electric lamps. In a recent paper published by the National Bureau of Standards at Washington, attention was called to the discrepancy between the candle unit obtained through the Harcourt 10 candle-power pentane lamp and that obtained from the Hefner by the use of the ratio 0·88.

In this same paper attention was also directed to the question of possible international action looking toward the establishment of a common unit of candle-power for England, France, and the United States. The units in use in these three countries are so nearly alike that, with the accuracy at present obtainable in industrial photometry, no serious results would follow a compromise by which all three countries would agree upon a common unit of candle-power. If the value of this common unit were taken as the average of the values of the units maintained at the national laboratories in the three countries, it would be very close to the mean between the two units in use in the United States in the photometry of gas and electric lamps. Therefore a compromise in the interest of international unity would require no greater changes of unit than a compromise in the interest of national unity. Moreover, the change in unit would in no case be greater than about two per cent, and the effect of such a change would not be seriously felt, even in the photometry of incandescent lamps where the highest accuracy in commercial testing is attainable.

Since the German unit of candle-power differs by 10 or 15 per cent from the average value of the units in England, France, and the United States, it would not seem desirable to include the German unit in taking the mean value. Either Germany could elect to adopt the international candle unit, or else the ratio of the Hefner candle to the international unit could be determined.

In consideration of the facts stated above, we, the undersigned, on behalf of the Sub-Committee of the Committee on Nomenclature and Standards of the Illuminating Engineering Society respectfully request, therefore, that the American Gas Institute appoint a committee to confer with the sub-committee of the Illuminating Engineering Society on the question of the possible adoption of a common national and international unit of candle-power.

A similar request is being made to the American Institute of Electrical Engineers, and it is hoped, through the co-operation of these two representative bodies, that some definite action will be taken.

Yours respectfully,

(Signed) EDW. P. HYDE.
J. B. KLUMPP.

This communication was referred to the Technical Committee of the Gas Institute for action, with the result that subsequently the following members were appointed to form a sub-committee of the Institute to confer with similar committees of the American Institute of Electrical Engineers and the Illuminating Engineering Society: Mr. W. H. Gartley, M. A. E. Forstall, Dr. A. H. Elliott, and Mr. C. O. Bond.

In a similar way an invitation to the American Institute of Electrical Engineers to appoint a sub-committee to unite in conference with sub-committees of the other two bodies to consider the question of the adoption of a common national and international unit of candle-power was presented to the Standardization Committee, at its meeting in New York Nov. 7th, 1907. The invitation was received favourably by the Standardization Committee, and the following sub-committee was appointed: Dr. A. E. Kennelly, Dr, Samuel Sheldon, Dr. C. P. Steinmetz. and Dr. S. W. Stratton.

The two sub-committees of the American Institute of Electrical Engineers and American Gas Institute held separate preliminary meetings, and passed resolutions expressing the attitudes of the respective sub-committees on the question of the adoption of a common unit of luminous intensity. In addition to the formal committee meetings, several informal joint conferences of representatives of gas and electric lighting interests were held, as the result of which a more thorough understanding of the present situation and of the necessity and probable effects of an agreement upon a common unit of candle-power was reached.

Finally on February 14th, 1908, in the Engineering Societies Building in New York the three sub-committees representing the American Institute of Electrical Engineers, the American Gas Institute, and the Illuminating Engineering Society, met in joint conference, and organized themselves into a joint committee with Dr. S. W. Stratton, permanent chairman, and Mr. C. O. Bond, permanent secretary. In the absence of Dr. Stratton, Dr. E. P. Hyde was elected chairman *pro tem* of the meeting. After a lively discussion the following preamble and resolutions were unanimously adopted:

"The joint Committee composed of sub-committees of the American Institute of Electrical Engineers, the American Gas Institute, and the Illuminating Engineering Society, recognizes that although the differences among the units of candle-power in use in the United States at the present time are not greater than a few per cent, nevertheless in view of the increasing accuracy that is being demanded in industrial photometry, there is a growing need of a common unit of candle-power which shall be established and maintained at the United States Bureau of Standards at Washington, D.C., and in terms of which secondary and working standards for use in the photometry of all kinds of illuminants can be measured. The Committee further realizes the importance and desirability of international agreement upon a common international unit of luminous intensity to be used throughout the civilized world. It so happens that the common unit which would be adopted in the United States as a compromise between the candle units used in the photometry of gas and electric lamps would approximate very closely to the mean value of the candle units maintained at the National laboratories of the United States, England and France. The unit of light maintained at the National laboratory in Germany (the Hefner) differs from the candle units maintained at the national laboratories of the other three countries by so great an amount that no benefit would accrue either to Germany or to the other countries by including the Hefner in taking the mean of the various units:

And Whereas the three sub-committees in joint conference deem that the above statements embody the consensus of opinion of said committees: therefore, be it—

Resolved: (1). That the joint committee, composed of sub-committees of the American Institute of Electrical Engineers, the American Gas Institute, and the Illuminating Engineering Society, approves the adoption of a common national candle unit which shall be maintained at the United States Bureau of Standards, and in terms of which secondary and working standards for use in the various industries can be standardized, and recommends to each of the three societies here represented through the respective sub-committees the adoption of such a plan.

Resolved: (2). That this committee will support the Bureau of Standards in any action which it may take to bring about international agreement upon a common candle unit, and will recommend to each of the three societies here represented the endorsement of such action, provided the unit agreed upon shall represent approximately the average value of the candle units maintained at present at the national laboratories of the United States, England, and France, or, specifically that it shall be lower than the unit at present maintained at the Bureau of Standards at Washington, D.C., by an amount not less than one (1) per cent,

nor more than three (3) per cent, the exact value to be agreed upon as the result of an international conference.

Resolved: (3). That inasmuch as the adoption at this time of a definite value for the common national candle unit for the United States would embarrass the Bureau of Standards in bringing about international action, this Committee refrains at this time from recommending the adoption of a definite value for the common national candle unit, but recommends, in the interest of the various industries involved, that during the interval required for the consummation of international action a common candle unit be used which shall be two (2) per cent. less than that now maintained at the Bureau of Standards, since there can be no doubt but that such a candle unit would differ by less than one (1) per cent from the proposed international candle; and further resolved that the Secretary of this joint committee is instructed, after the concurrence of the three societies here repreesnted, to address a letter to the Director of the Bureau of Standards enclosing a copy of these resolutions, and requesting that the Bureau of Standards, which has taken the initiative in the present movement toward a common national and international candle unit, maintain as its working candle from this time on until definite international action shall have been taken, a candle unit two (2) per cent lower than that which it is maintaining at the present time.

Resolved: (4). That this Committee recommends that each society here represented, acting through its own proper channels, shall address to such similar foreign societies as may be interested a statement of the movement in the United Sates toward a common international candle unit (enclosing a copy of these resolutions), and shall request the cooperation of the said foreign societies in advancing the movement."

In pursuance of these resolutions the sub-committee of the American Institute of Electrical Engineers reported the action of the joint Committee to the Board of Directors of the Institute for approval. The action of the sub-committee was endorsed, and the latter was authorized to notify the Secretary of the joint Committee to that effect, in accordance with Resolution 3.

In the Illuminating Engineering Society the resolutions of the joint Committee were endorsed by the Committee on Nomenclature and Standards, and referred by this committee to the Council of the Society. At a meeting of the Council, held June 12th, 1908, the action of the sub-committee was approved. Since authority in such matters is vested in the Council of the Illuminating Engineering Society and in the Board of Directors of the American Institute of Electrical Engineers, the final action by these two bodies has already been obtained.

Before the resolutions of the joint Committee can be approved finally by the American Gas Institute they must be presented to the society for action, at its annual convention, which is to be held in New York in October. It is encouraging to report, however, that the resolutions of the joint Committee have already been endorsed, both by the Technical Committee and subsequently, on March 17th, by the Board of Directors of the Institute. Should the Institute at its convention act favourably on the resolutions of the joint Committee, the Secretary of this committee will address a letter to the Director of the Bureau of Standards in accordance with Resolution 3, requesting that the Bureau "maintain as its working candle from this time on until definite international action shall have been taken, a candle unit two (2) per cent lower than that which it is maintaining at the present time."

The sub-committee on Nomenclature and Standards is authorized to report further that the Bureau of Standards has already entered into negotiations with the foreign laboratories in regard to the possible agreement upon an international unit of luminous intensity and that the hope is expressed that final agreement may be reached very shortly.

Design of the Illumination of the New York City Carnegie Libraries.

By L. B. Marks.

(Paper read at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1908.)

The design of the illumination of a public library involves considerations which are quite unlike those that ordinarily confront the illuminating engineer, and are in many respects more difficult to meet than in almost any other class of building. The design must secure :—

1. Sufficient illumination on the reading tables and book-shelves to meet so far as possible, removal of lights from the ordinary field of vision.

3. Sufficient illumination for the library staff to oversee the entire floor.

4. Sufficient illumination to provide a moderate reading light in all parts of the room, to admit of the relocation or addition of furniture, such as portable magazine filing racks, &c.

5. Moderate cost of installation.



Fig. 1.—First Floor, Carnegie Library.

the demands of a wide class of readers of various ages and conditions of eyesight, taking into account the fine print in some of the books and the difficulty of reading titles of books in position on the shelves. Some of the books are worn by frequent handling, and the titles become more or less obscured.

2. Low intrinsic brightness of light sources and freedom from glare, and,

6. Economy of operation. This must take into account not only the system of illumination and type of lamps used, but also the switching arrangements.

7. Simplicity in construction and convenience in operation. This must take into account the character of the help from those in local charge of the equipment.

8. Æsthetic design of fixtures, and

attractive appearance of the reading-rooms at night.

The present paper is a preliminary one, and deals with the design of illumination of the new Carnegie branches of the New York Public Library, and in particular with the St. Gabriel's Park branch, which is representative of seven other Carnegie Library buildings which are now under construction in New York City. The St. Gabriel's Park branch of which Messrs. McKim,

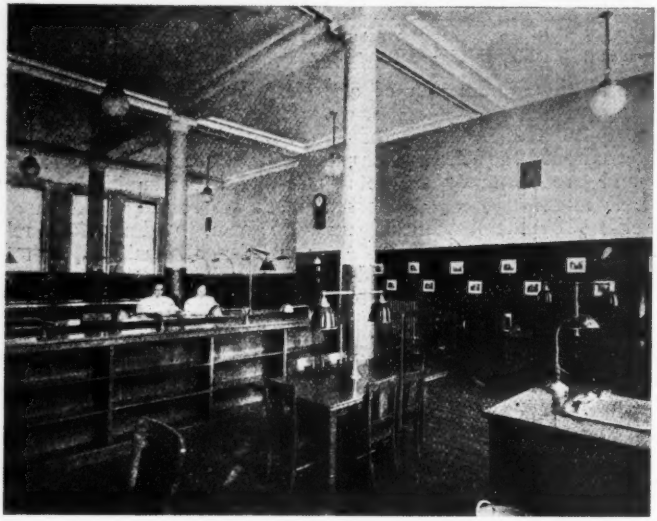


FIG. 2.—Second Floor, Carnegie Library.

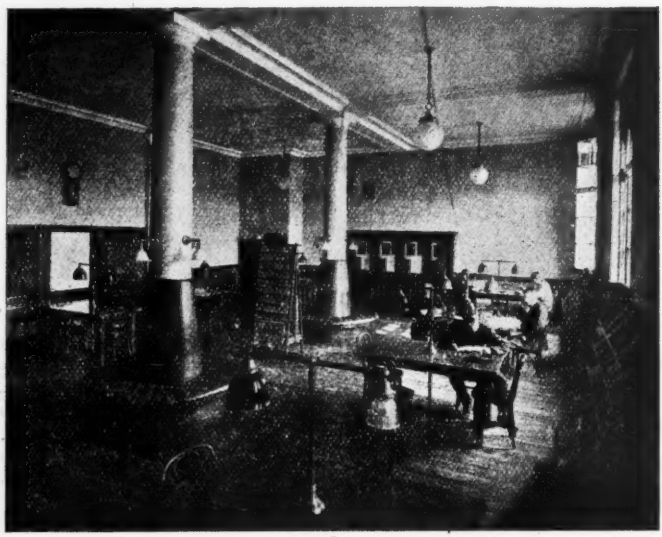


FIG. 3.—Third Floor, Carnegie Library.

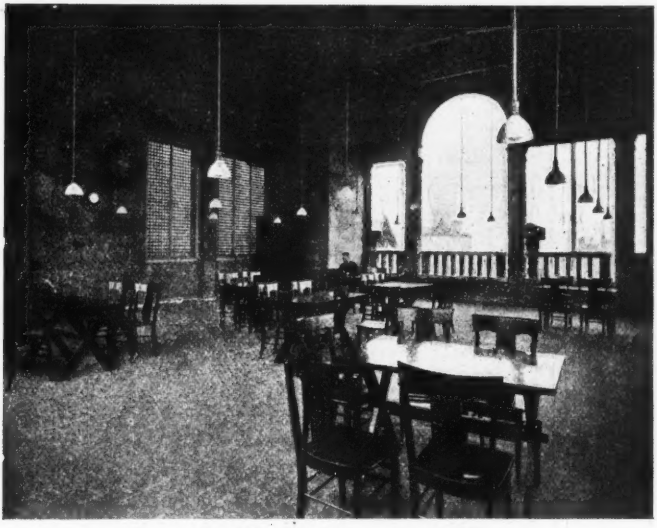


FIG. 4.—Roof Reading Room, Carnegie Library.

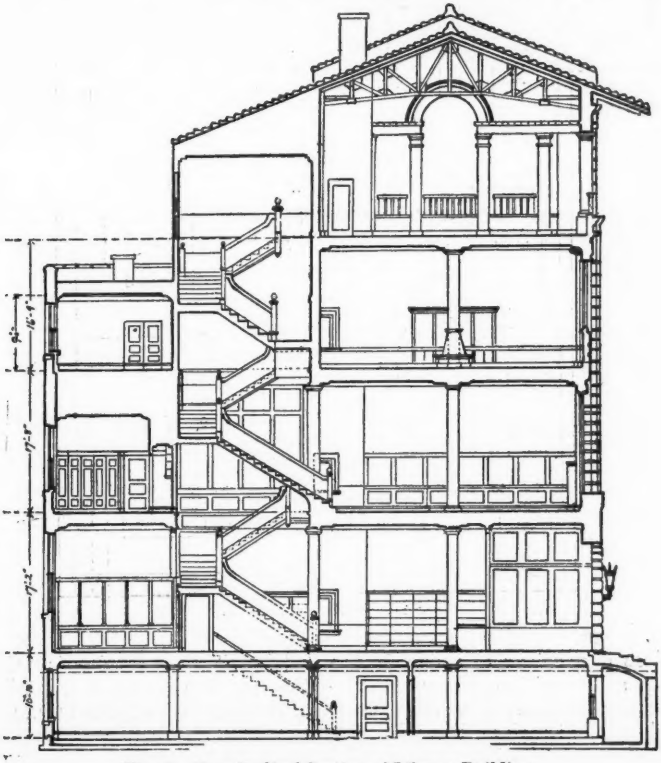


Fig. 5.—Longitudinal Section of Library Building.

Mead & White were the architects, was opened to the public a few months ago.

Drawings of floor plans—showing location of light outlets, switches, &c., units. Fixture drawings by Mr. W. S. Kellogg, supervising architect of the works, schedule of lamps, and photographs of the four main floors of the building, are also given.

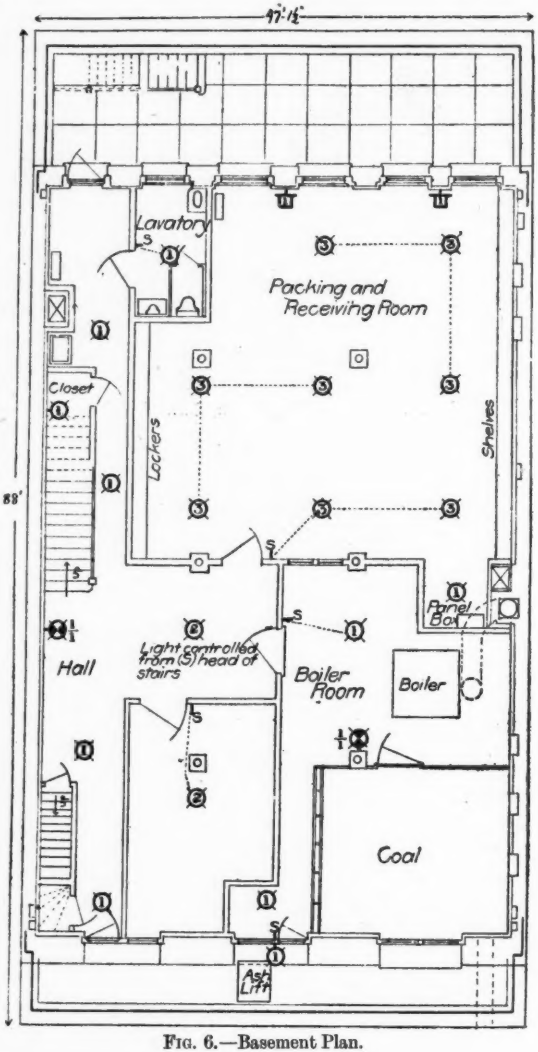


FIG. 6.—Basement Plan.

as well as dimensions of rooms in the building and position of furniture—are given herewith. The light units are designated at each outlet and shown on the plans on the basis of 50 watt

The lighting service is taken from the direct current three wire mains of the New York Edison Co., and enters the building in the basement, from which it is distributed throughout the

CARNEGIE LIBRARY, ST. GABRIEL'S PARK BRANCH.

FIXTURE AND LAMP SCHEDULE.

Basement. Height, 9′-6″.

No. of pieces	Drawing No.	No. of lamps. Gas.	No. of lamps. Elec.	Description of Lamps. Special.	Description of Lamps. Regular.	Height of Globe Holder.	Name of Room Location of Lamp.	Remarks.
1	4 A		1		16-c.p. Edison		Front area	Bracket lamp weather proof socket
2	15 A		2		16-c p. Edison Frosted	7′-0″	Boiler room Coal and ash	Ceiling pendant
1	3 A	1	1		8-c.p. Edison			Combination bracket
1	1 A		1		8-c.p. Edison			Electric bracket
4	15 G		4		16-c.p. Edison	7′-6″	Halls	1-lamp pendant 6″ ball R.O. 3-½″ holder
1	15 H		1		32-c.p. Edison	7′-8″	Halls	1-lamp pendant 8″ x 4″ C.R.O. 6″ ball
1	3 F	1	1		8-c.p. Edison		Hall at foot of stairs	1 combination bracket chain pull
1	1 F		1		8-c.p. Edison		Closet under stairs	Electric bracket lamp up, chain pull
1			1		16-c.p. Edison Frosted	At ceiling	Toilet	Electric ceiling outlet prismatic
1	17 B		1		16-c.p. Edison Frosted tip	7′-6″	Work room by B. L.	1-lamp pendant ch. pull
8	6 B		24		16-c.p. Edison Frosted tip	7′-6″	Work room ceiling	Ceil. pendant distance x on draw = 1′-0″ each 3 electric
1	15 A		1		32 c.p. Edison	9′-0″	Store room	1-lamp pendant
2			1		16-c.p. Edison Frosted			2 flexible portables with fluted glass shades

First Story. Height, 15′-3″.

No. of pieces	Drawing No.	No. of Lamps. Gas.	No. of Lamps. Elec.	Description of Lamps. Special.	Description of Lamps. Regular	Height of Globe Holder.	Name of Room Location of Lamp.	Remarks.
1	18		1		187-watt Gem	12′-6″	Ent. vest.	1-lamp pendant 16″ C. R. O.
1	2	1					Ent. vest.	Gas wall bracket
1	3 F	1	1		8-c.p. Edison		Top of stairs by ent. vest.	1-lamp bracket, smoke bell over, chain pull
2	19		12		8-c.p. Edison Frosted tip	7′-3½″	On west wall over swinging frames	
1	3 F	1	1		8-c.p. Edison		Foot of stairs up	1 combination bracket chain pull
1	1 F		1		8-c.p. Edison		Under main stairs on the landing to basement	1 electric bracket, lamp up, chain pull
2	5 B		4		16-c.p. Edison Frosted tip		Office	2-lamp brackets, chain pull
4	5 B		8		16-c.p. Edison Frosted tip		Reference Room	2-lamp brackets Proj. 15″ from wall to centre of lamp, lamps down, chain pull
1	1 B		1		16-c.p. Edison Frosted tip		Book lift	1-lamp bracket, lamp down, chain pull
9	18		9		16-c.p. Edison	12′-6″	Main room	Ceiling pendant 16-in C. R. O. ball
2	10		4		16-c.p. Edison Frosted		Shelves in office	2 mirror reflectors
10	10		20		16-c p. Edison		7 shelf cases in main rm.	Mirror reflectors
20	9		20		8-c.p. Edison		3 shelf cases in main rm.	Revolving fixtures
9	R 7 D		18		20 c.p. 50-watt Gem	7′-2″	4 shelf free standing cases	Exact spread of arms given later (about 5′-6″)
3	8 E		3		16-c.p. Edison Frosted		Delivery desks	Adjustable revolving standard
3	14		3	40-watt Tantalum Frosted			Circulation room	On round tables
1	14		1	40-watt Tantalum Frosted			Reference room	On round tables
4	L 7 C		8		16-c.p. Edison Frosted		Reference room	Rectangular tables, distance x = 1′-6″ for 6′-0″ table and 1′-3″ for 5′-0″ table
2			2	16-c.p. Edison Frosted				2 flexible portables with fluted glass shades.

Second Story. Height, 15′-6″

No. of pieces	Drawing No.	No. of Lamps. Gas.	No. of Lamps. Elec.	Description of Lamps. Special.	Description of Lamps. Regular.	Height of Globe Holder.	Name of Room Location of Lamp.	Remarks.
1	3 F	1	1		8-c.p. Edison		Stair landing 1st to 2nd	Combination bracket chain pull
1	3 F	1	1		8-c.p. Edison		Foot of stairs up	Combination bracket, chain pull
1	1 B		1		16-c.p. Edison Frosted tip		Book lift	Bracket, lamp down, chain pull
2	5 B		4		16-c.p. Edison Frosted tip		Rear of circulation room	2-lamp bracket, lamps down, lamps 15″ from wall, chain pull
4	1 B		4		16-c.p. Edison Frosted tip		Column over seat	1-lamp bracket, lamps down
1	1		1		8-c.p. Edison		Slop sink	Lamp down, no shade, chain pull
1			1		16-c.p. Edison Frosted tip		Toilet	Electric ceiling outlet, prismatic
1	6 B		6		16-c.p. Edison Frosted tip	7′-6″ (ceil. 12′-0″)	Librarian's Room	6-lamp ceiling pendant x = 1′-3″
2	1 B		2		16-c.p. Edison Frosted tip		Librarian's room	brackets, lamp down, chain pull
16	9		16		8-c.p. Edison		3 shelf cases	Revolving bracket
11	11		22		16-c.p. Edison		5 shelf cases	Mirror reflector
4	11		8		16-c.p. Edison		Bulletin board	Mirror reflector
2	14		2	40-watt Tantalum Frosted			Circulating room	Round tables
4	L 7 C		8		16-c.p. Edison Frosted tip		Reference room	Rectahgular tables, Dist. x = 1′-6″ for 6′-″ tables and 1′-3″for 5′-0″ tables
3	8 E		3		16.c.p. Edison Frosted tip		Delivery desk	Revolving Adj. Standard
9	18		9		187-watt gem	12′-6″	Ceiling, main room	16″ C. R. O. Pendant balls

Third Story. Height, 15′-0″.

Janitor's Apartments. Height, 9′-0″.

No. of pieces	Drawing No.	No. of Lamps. Gas.	No. of Lamps. Elec.	Description of Lamps. Special.	Description of Lamps. Regular.	Height of Globe Holder.	Name of Room. Location of Lamp.	Remarks.
6	18		6		187-watt Gem	12′-6″	Ceil. main room (reading)	16″ C. R. O. Pend. balls
3	3 F	3	3		8-c.p. Edison		Comb. brackets on stairs, Ch. p.	
2	3 F	2	2		8-c.p. Edison		Janitor's Hall	Comb. brackets, Smoke bells, Ch. p.
4	3 F	4	4		16-c.p. Edison		Janitor's bed rooms	Comb. brackets, Smoke bells, Ch. p.
1	3 F	1	1		16-c.p. Edison		Janitor's bath	Comb. brackets, Smoke bells, Ch. p.
1	6 G	4	4		16-c.p. Edison	6′-6″	Janitor's living room	Comb. ceiling pendant, x = 1′-0″
1			4		16-c.p. Edison Frosted	8′-0″	Kitchen ceiling	Cluster porcelain reflector
1	3 F	1	1		16-c.p. Edison Frosted		Kitchen wall	Comb. bracket over tubs Ch. p.
1	1 A		1		8-c.p. Edison		Janitor's stairs to roof	Lamp up
10	13		10	Straight filament lamps			Reading room, ex. cases	Johns-Manville Co. "Linolite"
2	1 B		2		16-c.p. Edison Frosted		Reading room over folio cases	Lamp down 15″ from wall Ch. p.
8	1 B		8		16-c.p. Edison Frosted		Reading room, Cols. over seats	Lamp down 15″ from wall Ch. p.
1	1 B		1		16-c.p. Edison Frosted		Book lift	Lamp down Ch. p,
9	L 7 C		18		16-c.p. Edison Frosted		Reading room tables	x = 1′-6 -″ for 6′-″ table and 1′-3″ for 5′-0″ table
2			2		16-c.p. Edison Frosted			2 flexible portables with fluted glass shades

Roof. Height, 20'-0" to truss.

No. of pieces	Drawing No.	No. of Lamps. Gas.	No. of Lamps. Elec.	Description of Lamps. Special.	Description of Lamps. Regular.	Height of Globe Holder.	Name of Room. Location of Lamp.	Remarks.
3			3		32-c.p. Edison Frosted	8'-0"	Hall	1-lamp, electric pendants Prismatic enamelled
2	2	2					N. wall	Gas brackets
2	1 A		2		16-c.p. Edison		Book lift and motor room	Ch. p.
23	16		16		125-watt Gem with frosted tip	7'-0"	From stair platform to shade holder	Enamelled reflectors

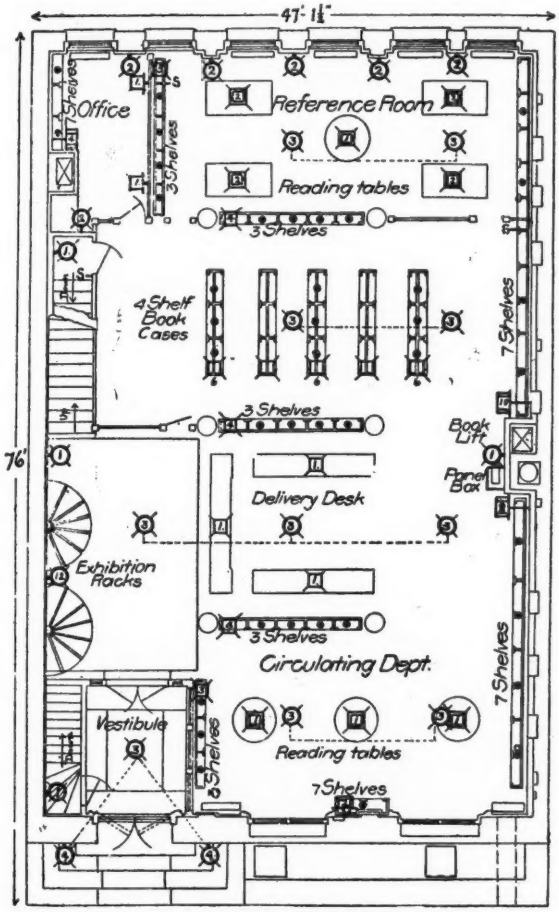


FIG. 7. - First Floor Plan.

building through panel boxes located on each floor. These panel boxes contain the switches which control the individual circuits.

DESCRIPTION OF ROOMS.

Basement.—The basement contains the packing and receiving room, boiler room, coal vault, store-room, and

lavatory. The walls and ceilings of this room are white in colour.

First Floor.—The main entrance to the building is on the first floor. With the exception of the vestibule and small office, which are separated from the rest of the room by glazed partitions, this floor constitutes one large room. In the front of the room is the white. The public has access to all of the bookshelves. In the entrance hall are located two exhibition racks of the swing frame type. The switches for controlling the lights are in charge of the librarian.

Second Floor.—This floor contains the children's reference-room and circulating department, and the librarian's

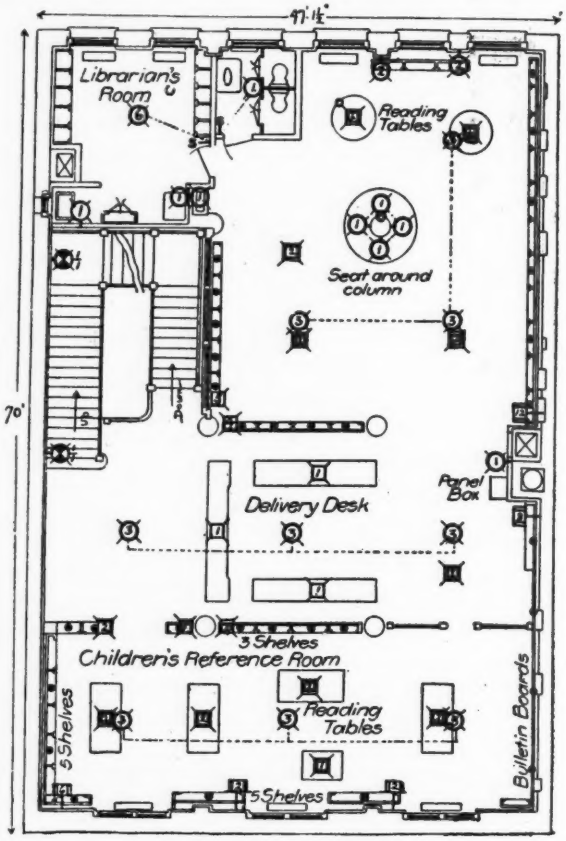


FIG. 8.—Second Floor Plan.

circulating department, in the middle the application and delivery desk, and in the rear portion the free standing book stacks and the reference room. These departments are separated from each other by low rails or low book shelves. Along the walls of the room are book-cases about 7 ft. high. The walls are cream coloured and the ceiling room. The conditions are very much the same as on the floor below.

Third Floor.—The main reading-room and the janitor's apartments are on the third floor. In addition to the reading-tables in the main room, there are two circular seats for readers around the columns; also two exhibition cases for the display of photographs,

prints, &c. The room contains portable magazine and newspaper racks, but has no bookshelves.

Roof.—The roof is used as an open-air reading-room. The floor of this room is of dark coloured tile, the walls red brick, and the ceiling formed by a roof of dark coloured tile, supported on trusses.

ILLUMINATING TESTS.

Tests of illumination were made under my direction by the Electrical Testing Laboratories, on the first floor and in the roof reading-room.

The first floor dimensions are approximately 67 ft. by 44 ft., and the height of the ceiling is 15 ft. 3 in. in the clear. General illumination is provided by 10, 187 watt ceiling pendant lamps each equipped with a prismatic reflector, both lamp and reflector being enclosed in a 16 in. crystal globe roughed on the outside. The height of the lamps above the floor is 12 ft. 6 in. The localized illumination is provided on the reading-tables, stacks, book shelves, &c., and may be used in whole or in part depending upon the requirements, permitting lamps in the reading-tables or on the bookshelves, to be extinguished when not required.

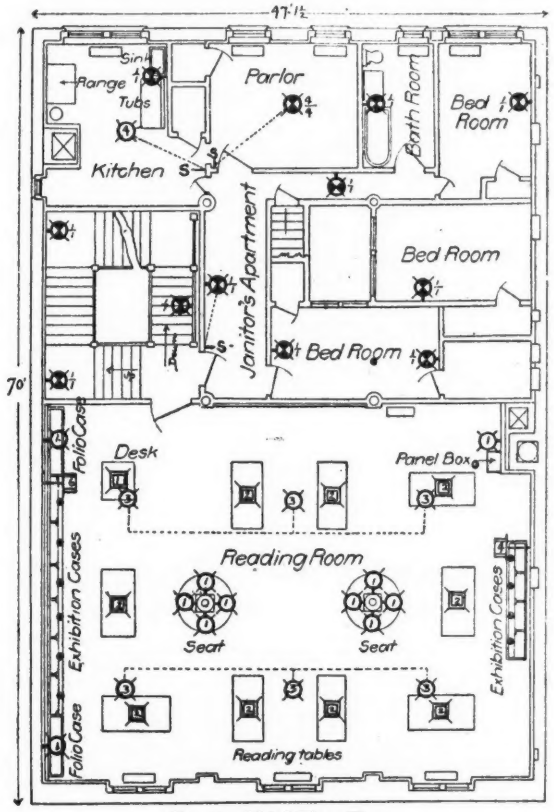


FIG. 9.—Third Floor Plan.

The free standing bookcases located near the rear of the room are 52 in. high and 9 ft. 6 in. long, divided into four shelves 9 in. apart. These are illuminated by 50 watt Gem lamps, backed by prismatic reflectors which

are covered by opal shades, green on the outside, shown in elevation in the illustration. These are located 6 ft. 6 in. above the floor, and immediately over the centre of the aisles between stacks as illustrated on the diagram.

The seven shelf bookcases upon which tests were made are illuminated by 3 candle-power carbon filament incandescent lamps on swing brackets, which, when in use, extend 9 in. beyond the edge of the case, but when out of use are swung over the top of the rack in order to leave maximum aisle space. These lamps are 44 in. above the floor and 6 in. above the top of the case. They are backed by opaque metal reflectors.

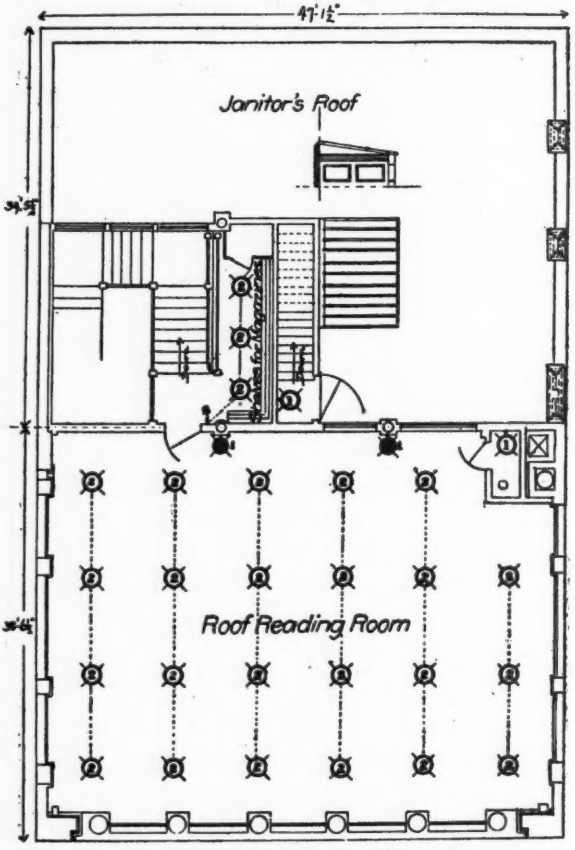


FIG. 10.—Roof Reading Room Plan.

special two-socket mirror trough wall reflectors holding the lamps in a horizontal position, and equipped with 50 watt Gem lamps, The location of these reflectors is illustrated in the diagram.

Tests were made upon the low bookcases along the aisles. These cases are provided with local illumination from

The round reading-tables shown on the drawings are provided with local illumination from 40 watt frosted tantalum lamps in single lamp fixtures, having 14 in. opal dome shades, green on the outside. Immediately over the lamps and inside the dome shades are placed prismatic reflectors. These fixtures are placed at the centres of the

tables, with the tantalum lamps 20 in. above the table top.

The rectangular tables, 3 ft. × 5 ft., in the rear of the room are illuminated by frosted 16 candle-power Edison lamps, equipped with reflectors of

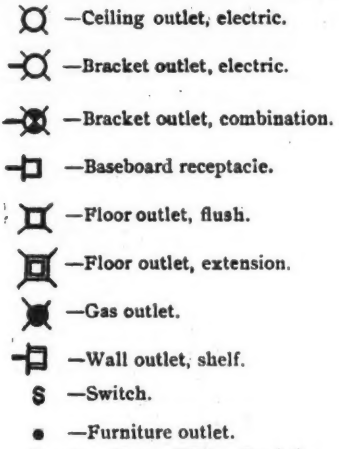


FIG. 11.—Key to Wiring Symbols.

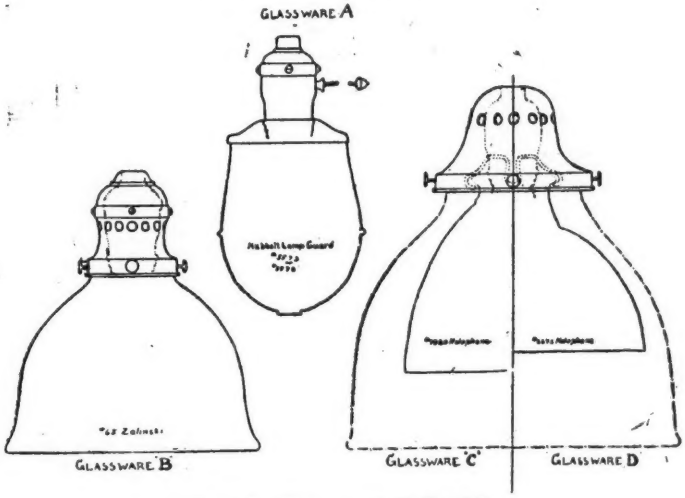


FIG. 12.—Glasswares A, B, C and D.

the same type as those used on the round reading tables. The test was made on one of the tables, which was equipped by mistake with 40 watt tantalum lamps instead of 16 candle-power Edison lamps, and the error was not discovered until it was too late to complete further measurements with lower candle-power lamps in time for presentation in this paper.

A plan of the roof reading-room is given, showing the approximate location of tables and light sources. In this case 125 watt tip-frosted Gem lamps are used in conjunction with a temporary installation of prismatic reflectors sand blasted inside. The tables are not fixed as in the floors below.

CONDITIONS OF TEST.

Most of the lamps in this installation were installed over two months ago, and have experienced a normal amount of service since installation. As slight fluctuations in voltage were to be anticipated, and as it was desired to obtain results which would be free from the influence of such fluctuations, it was decided to make the photometric comparisons with a standard lamp operated from the lighting system, and subject to the same fluctuations in voltage as were the lamps which were under test. Under these conditions accurate results are secured, which are intercomparable.

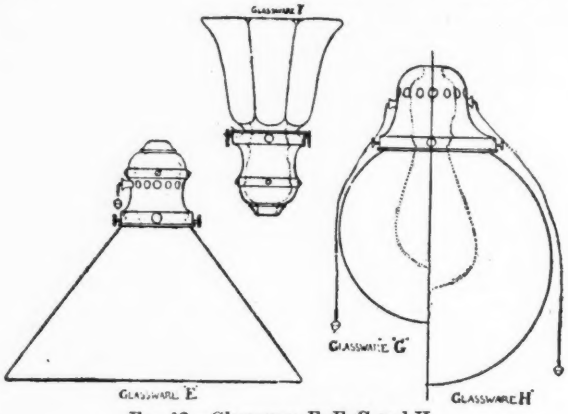


FIG. 13.—Glasswares E, F, G and H.

On the first floor tests were made to show the amount of general illumination, and also to show illumination produced by both the ceiling lamps provided for general illumination and the lamps provided for local illumination.

METHODS OF TEST.

The intensity of vertical illumination was measured at points on the fronts of sticks and bookshelves where it is desired to read titles on the backs of books. Tests were also made of horizontal illumination in aisles immediately in front of stacks to show illumination on books opened and held in such positions for casual inspection Other tests of horizontal illumination were made upon reading tables.

In conducting these tests a Sharp-Millar portable photometer was used. In tests of vertical illumination at the book-stacks the photometer was placed on the shelves with the illumination test plate vertical, and in the position occupied by the title of a book. An observation under these conditions is equivalent to viewing the title from a point directly in front or to viewing the test plate from a point in a line normal to its surface. Other tests of the same values were made by placing a piece of blotting paper (used as a test plate) vertically over the backs of the books, and observing it through the photometer located at the point from which one would naturally view the titles of the books in practice. This constitutes a determination of the illumination intensity through observation of the test surface at angles varying from 45 degrees above to 40 degrees below the normal, depending upon the height of the shelf.

In all cases the illumination is stated in terms of that produced by a standard lamp placed at a known distance from the test-plate, which was viewed as in the test.

(To be continued.)

The Illuminating Value of Petroleum Oils.

By Dr. Arthur H. Elliott.

(Paper read at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1908; slightly abbreviated.)

The author describes a number of tests on oil-lamps, the object being to secure some lamp or flame that would serve as a secondary standard for photometric work; these comprise experiments made with a number of lamps and also with various petroleum oils of high and low density.

The small lamps used are found in commerce with glass reservoirs and 0·5 in. and 1·0 in. cotton wicks. Use was made also of lamps with two wicks, where in one case both wicks go through the same burner slot, and in the other case, each wick has a separate slot in the top of the burner. Two lamps with round wicks were also used.

The oils used have been the best grade kerosene oils of 48° to 50° Beaumé, and 150° flash; heavy burning oil, 40° Beaumé, 300° flash; gas oil, distilled to eliminate residuum, of 35° Beaumé; and a mixture of kerosene oil with heavy 300° flash oil, the mixture having a density of 45° Beaumé. The burners used are what are termed in commerce "Queen Anne," "Climax," "Dual," "Duplex," "Rochester," and "Belgian."

In starting these investigations, the work done by others was naturally looked over and very little of this kind of work was found on record, with the exception of some work done by Stevenson Macadam, F.R.S.E., who about the year 1870 conducted some experiments on the illuminating value of mineral oils and compared them with sperm oil, rape oil (colza), and whale oil. Table A gives a résumé of his results and a comparison of the mineral oils, with others mentioned.

Table A.—Illuminating Value of Oils. Macadam.

Lamp used	Small flat flame		Medium flat flame		Large flat flame	
Oil used	Grains per hour	Candle-power	Grains per hour	Candle-power	Grains per hour	Candle-power
Paraffine (Shale) ... Uphall & Young ...	328	6·0	492	9·0	656	12·0
Value of 120 grns. of paraffine oil per hour	120	2·195	120	2·195	120	2·195
Sperm	180	1·306	—	—	—	—
Rape (Colza) ...	170·6	1·05	—	—	—	—
Whale	153	0·90	—	—	—	—

TABLE A (continued).

Lamp used	¾-in. Argand		1-in. Argand	
Oil used	Grains per hr.	Candle power	Grains per hr.	Candle power
Paraffine (Shale) Uphall & Young.	494	9·0	975	19·83
Value of 120 grns of paraffine oil per hour ...	120	2·195	120	2·719
Sperm	—	—	1006	13·0
Rape (Colza) ...	—	—	933·2	11·33
Whale	—	—	853	9·8

In the investigations tabulated in Tables B, C, &c., two methods of procedure have been used.

Each lamp was tested against a pair of standard sperm candles, burning within the regulation limits of 120 grains of sperm for each candle per hour. The relative variation in the illuminating power was then calculated, designating the maximum illuminating power as 100, and the others as percentages.

Each of the readings across the table indicates hourly observations, and it will be seen that in many cases these observations run over a large number of hours. Moreover, the quantity of oil, in grains, burning one hour, to give one candle-power, was calculated, in order to compare it with the standard sperm candle—the light obtained from sperm burned at the rate of 120 grains per hour. This gives a direct comparison between sperm and the same weight of any oil used. Some of these figures are extremely interesting, as indicating the high value of petroleum oils of good quality, as compared with sperm oil.

TABLE C.

Queen Anne Burner. One ⅛-in. wick. 6 hours. Burning 308·64 grains of oil per hour.

Candle-power.	Variation of Illuminating Value.
4·90	98·00
5·00	100·00
5·01	100·00
5·01	100·00
5·00	100·00
5·00	100·00
Average 4·987	99·70

1 c.p.-hour requires 61·98 grains of oil.
120 grains of oil per hour = 1·936 candle-power.
Variation of standard during test, 10·25 to 10·21 c.p.

TABLE B.—EXPERIMENTS WITH VARIOUS LAMPS, USING KEROSENE OIL.
Oil not measured.

Burner used	Time	Candle-power	Illumination
Queen Anne, ⅛-in.	10 minutes	5·59	90·7
" " "	2½ hours	6·16	100·0
" " "	4 hours	6·16	100·0
Queen Anne, 1-in.	15 minutes	8·64	98 5
" " "	1¾ hours	8·77	100 0
" " "	3¾ hours	8·56	97 6
Climax, 1·5-in., with height gauge	10 minutes	6·88	98·00
" " " " "	1 hour	6·79	96·7
" " " " "	2 hours	7·02	100·00
Climax, 1·5-in. wick, 1-in. height gauge. Student feed	10 minutes	11·67	93·5
Climax, 1·5-in. wick, 1-in. height gauge. Student feed	1½ hours	12·51	99 5
Climax, 1·5-in. wick, 1-in. height gauge. Student feed	3 hours	12·60	100 0

TABLE B (continued).

Burner used; Climax, 1.5-in. wick, 1-in. height gauge. Student feed.

Time.	Candle-power.	Illumination.
5 hours	11·67	92·6
30 minutes	15·09	100·0
3½ hours	14·96	99·1
5½ hours	14·83	98·3
7 hours	14·52	96·2
10 minutes	14·92	99·1
2 hours	14·73	97·9
5 hours	14·97	99·5
7 hours	15 05	100·0

TABLE D.

Kerosene, Queen Anne burner. One 1-in. wick 6 hours. Burning 618·98 grains of oil per hour

Candle-power.	Variation of Illuminating Values
10·83	98·71
10·87	99·08
10·87	99·08
10.97	100·00
10·97	100·00
10·97	100·00
Average 10·913	99·48

1 c.p.-hour requires 55·71 grains of oil.
120 grains of oil per hour = 2·114 candle-power.
Variation of standard during test, 10·18 to 10·14 c.p.

The tables serve to indicate the steadiness and reliability of the flat-flame lamps, even when burned with common reservoirs where the level of the oil varies as the lamp burns; it will be noted that the rate of consumption and the candle-power are extremely constant. Many of the lamps used gave nearly twice the candle-power of sperm candles for the same weight of oil, while the round-wick lamps gave fully three times as much.

In the early experiments the lamps were adjusted by the eye; that is to say, the height of the flame was deter-

mined, and not changed during the experiment, attention being paid only to obtaining the best light. In later experiments, a wire gauge above the flame served to determine its height in the case of flat-flame burners; this arrangement was found impracticable with the round burners. Under these circumstances, it was found that a flat-flame burner would operate several hours with a loss of less than 5 per cent in its candle-power, and in many cases only 2 or 3 per cent. The form and height of the flame, of course, determine its candle-power, but this condition was not considered of so much import-

TABLE E.

Kerosene, Dual Burner. Two 1-in. wicks. 6 hours. Burning 540·12 grains of oil per hour.

Candle-power.	Variation of Illuminating Value.
8·83	200·00
8·72	98·75
8·72	98·75
8·80	99·66
8·80	99·66
8·80	99·66
Average 8·78	99·413

1 c.p.-hour requires 61·51 grains of oil.
120 grains of oil per hour = 1·951 candle-power.
Standard unchanged during test.

TABLE F.

Kerosene, Duplex Burner. Two 1·5-in. wicks. 6 hours. Burning 1208·32 grains of oil per hour.

Candle-power.	Variation of Illuminating Value.
22·60	98·70
22·70	99·13
22·70	99·13
22·80	99·56
22·80	99·56
22·90	100·00
22·75	90·35

1 c.p.-hour requires 53·11 grains of oil.
120 grains of oil per hour = 2·259 candle-power.
Variation of standard during test, 10·00 to 10·07 c.p,

TABLE G.

Kerosene, Rochester Burner. One round wick 1·5-in. diameter. 6 hours. Burning 1898·17 grains per hour.

Candle-power.	Variation of Illuminating Value.
34·4	99·71
34·2	99·13
34·5	100·00
34·1	98·84
34·2	99·13
34·2	99·13
34·66	99·32

1 c.p.-hour requires 55·40 grains of oil.
120 grains of oil per hour = 2·166 candle-power.
Variation of standard during test, 10·12 to 10·00 c.p.

TABLE H.

Kerosene, Belgian Burner. One round wick, 1¼-in. in diameter. 6 hours.
Burning 1539·11 grains of oil per hour.

Candle power	Variation of illuminating value
39·5	99.49
39·6	99·d5
39·6	99·75
39·6	99·75
39·7	100·00
39.6	99·75
Average 39·6	99·75

1 c.p.-hour requires 38·86 grains of oil.
120 grains of oil per hour = 3·08 candle-power.
Variation of standard during test, 10·08 to 10·01 c.-p.

TABLE I.

Summary of Six Hour Tests. Kerosene.

Burner used	Queen Anne	Queen Anne	Dual	Duplex	Rochester	Belgian
Size of wick	½-in.	one 1-in.	two 1 in.	two 1·5-in.	1·5-in.	1¼-in.
Grains oil per hour ...	308·64	618·98	540·12	1208·32	1898·17	1539·11
Average candle-power	4·987	10·913	8·78	22·75	34·26	39.60
Average per cent illumination	99·70	99·48	99·41	99·35	99 32	99 75
One c.-p. hour requires grains of oil ...	61·98	56·71	61·51	53·11	55·40	38·86
120 grains of oil per hour = candles ...	1·936	2·114	1·951	2·259	2·166	3·080

ance as obtaining a steady flame burning at a uniform rate and giving a constant candle-power. The trimming of the wick determines the shape and height of the flame and also its freedom from smoke. Many of the lamps of flat-flame without any adjustment of level in the reservoir, were used for as

TABLE J.

300° Flash Oil, 40·4° Beaumé, Dual Burner. Two 1-in. wicks. 4 hours. Burning 459·87 grains of oil per hour.

Candle-power	Variation of illuminating value
6·34	100·00
5·73	90·3
5·93	93·5
5·56	87·7
Average 5·890	92·9

1 c.p.-hour requires 77·7 grains of oil.
120 grains of oil per hour = 1·544 candle-power.
Standard unchanged during test.

long as seven hours with a change of less than 5 per cent in the candle-power.

As will be seen from the tables, the heavy oils cannot be burned in small, single-wick, flat-flame lamps, since the burning temperature of the cotton wick is lower than the burning temperature of the oil. Furthermore, the density

TABLE K.

Oil Mixture (Half Kerosene, Half 300° Flash). Dual Burner. Mixture = 44·5° Beaumé at 60° F. Two 1-in. wicks. 4 hours. Burning 544·75 grains of oil per hour.

Candle-power	Variation of illuminating value
9·01	100·0
8·93	99·1
9·01	100·0
8·91	98·9
Average 8·965	99·5

1 c.p.-hour requires 60·8 grains of oil.
120 grains of oil per hour = 1·975 candle-power.
Standard unchanged during test,

of the oil prevents its rising sufficiently rapidly in such wicks. The experiments were therefore conducted with double wicks. These remarks are true of both the 300° flash oil and also the distilled gas oil.

In later experiments, a reservoir with a student lamp feed was used for the flat-flame burners; in this case the light was constant over six or seven hours with a variation of less than 1 per cent in the candle-power, tested by both standard sperm candles, and also secondary standards and electric

TABLE L.

Oil Mixture (Half Kerosene, Half 300° Flash). Queen Anne Burner. One 1-in. wick. 4 hours. Mixture = 44·5° Beaumé at 60° F. Burning 542·69 grains of oil per hour.

Candle-power	Variation of illuminating value
7·70	100·0
7·65	99·3
7·15	93·0
7·00	91·0
Average 7·375	95·8

1 c.p.-hour requires 73·6 grains of oil.
120 grains of oil per hour = 1·630 candle-power.
Standard unchanged during test.

units. Even an oil as low in density as 44° Beaumé in seven hours lost only 5·5 per cent of its photometric value. It was even found possible to place two lamps of the same photometric value opposed to one another on a

TABLE M.

Oil Mixture (Half Kerosene, Half 300° Flash). Climax Burner. Student feed. One 1·5-in. wick. 7 hours. Oil mixture, 44·5° Beaumé. Tested for variations of candle-power with time.

Time	Candle-power
9.30 A.M.	15·05
10.30 "	14·85
11·30 "	14·43
12.30 P.M.	14·43
1.30 "	14·33
2.30 "	14·33
3.30 "	14·23
4.30 "	14·23
7 hours	14·485 Average c.p.

Maximum candle-power ...	...	15·05
Minimum candle-power ...	...	14·23
Variation of candle-power	...	·82

Variation 100 to 94·55.
Standard unchanged during test.

photometric bench, and obtain only 0·02 candle-power variation in five hours.

It will be seen from Table P that the oil used in a lamp replenished from day to day during one week, is of practically the same character at the

end of the week as it is at the beginning. This fact demonstrates that the wicks carry the oil uniformly, and do not separate the various constituents of the oil, and fully accounts for the uniformity of burning and constant candle-power.

TABLE N.

Gas Oil (Distilled), 35·3° Beaumé, 0·847 Specific Gravity, Dual Burner. Two 1-in. wicks. 6 hours. Burning 578 70 grains of oil per hour.

Candle-power	Variation of illuminating value
8·18	100·0
8·18	100·0
8 18	100·0
8·18	100·0
8·12	99·26
8·12	99·26
8·12	99 26
Average 8·16	99·68

1 c.p.-hour requires 70.9 grains of oil.
120 grains of oil per hour = 1·692 candle-power.
Variation of standard during test, 10·32 to 10.30 c.p.

In conclusion the author acknowledges the service rendered by the Consolidated Gas Company of New York and also that of his three assistants, Messrs. Ihart, Regan, and Morhous.

TABLE O.

Gas Oil (distilled), 35·3° Beaumé, 0·847 specific gravity, Duplex Burner. Two 1·5-in. wicks. 6 hours. Burning 657·4 grains of oil per hour.

Candle-power.	Variation of Illuminating Value.
14·40	100·0
14·30	99·3
14·10	98·0
13·70	95·1
13·40	93·0
13·20	91·6
13·10	91·0
Average 13·74	95·4

1 c.p.-hour requires 45·9 grains of oil.
120 grains of oil per hour = 2·614 candle-power.
Variation of standard during test, 10·00 to 10·06 c.p.

TABLE P.

Climax Burner, lamp one week burning, using Kerosene. Test of variation of oil.
Oil at start, 49·1° Beaumé, 60° Fahr.
Oil at finish, 49·0° Beaumé, 60° Fahr.

	DISTILLATION.			
	320°–400° F.	500°–600° F.	500°–600° F.	Residuum. 600°–660° F.
Start	47·2 p. cent. 52° Bé.	42·8 p. cent. 47° Bé.	9·8 p. cent. 41·0° Bé.	3·2 p. cent.
Finish	46·0 p. cent. 52° Bé.	42·0 p. cent. 47° Bé.	10·0 p. cent. 41·5° Bé.	2·0 p. cent.

Standard Conditions for Testing Oil-Lamps.

In connexion with Dr. A. H. Elliott's exhaustive series of tests on this subject, it may be of interest to recall the papers read by M. Pihan and Herr Curt Proesdorf, at the International Petroleum Congress at Bucharest in 1907 (see *The Illuminating Engineer*, Jan., 1908, p. 79). On this occasion M. Pihan described the use of the Carcel lamp for making standard tests on oil-lamps and Herr Proesdorf described some experiences with 150 different types of lamps.

Subsequently, some further interesting particulars of tests on these lines were described by M. Guiselin in the *Journal du Pétrole* (see *The Illuminating Engineer*, March, 1908, p. 244).

The Intrinsic Brightness of Lighting Sources.

By J. E. Woodwell.

(Paper read at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1908; slightly abbreviated.)

The author commences his paper by commenting upon the importance of intrinsic brilliancy of illuminants, especially at the present day, when brighter sources are being introduced; and this brightness can be intensified by the use of reflectors. He mentions some other recent papers dealing with the subject.*

Briefly, any brilliant source of light in the field of view, however small, causes a contraction of the pupil of the eye, and reduces the effect of illumination received from other parts of the visible field. A contraction of the pupil also takes place, even if the bright spot is viewed only occasionally. Furthermore, the continuous or occasional presence of a bright light source in the field of view impairs, temporarily at least, the sensitiveness of the eye itself, thus again reducing the effectiveness of illumination. Moreover, the contraction of the iris in the presence of bright light sources soon reaches the limit of its protective faculty, beyond which it responds feebly to an increase in brightness. The control of the pupillary aperture appears to be designed to strengthen the vision under comparatively weak illumination, rather than to protect against excessive intensity or brightness.

Recent researches of André Broca and F. Laporte† indicate that the pupillary contraction caused by bright light sources within the peripheral vision reduces visibility in proportion to the decrease in working illumination, and produces the greatest eye fatigue in comparatively weak illumination. The exhaustion and injurious effect was greatly reduced, on the other hand, under an illumination of from 1·86 to 3·72 foot-candles.

The *intrinsic brightness* of the lumious source rather than the *distance* of the source from the eye was shown to be the principal cause for pupillary constraction. The different light sources could be classed—with reference to their action in producing pupillary contraction and residual images—in the order of their respective intrinsic brightness. These researches also suggest that the protective faculty of the eye is not susceptible to the energy effect or to light rays of different colour.

Ultra-violet rays have been regarded by some authorities as harmful, but it has been shown that these rays in the light from various forms of incandescent illuminants of high intrinsic brightness are, with few exceptions, much less than in direct or even reflected sunlight. Other invisible radiation of much more harmful character may accompany not only the newer light sources of high incandescence, but those of lower temperature as well.

The more important hygienic effects of light sources of high intrinsic brilliancy within the field of vision may then be summarized as follows :—

1. Contraction of the pupil is caused, thereby reducing the amount of light entering the eye and the consequent visibility.

2. The sensibility of the visual organs is temporarily impaired by residual images and retinal fatigue.

3. The effects of (1) and (2) are also produced by the occasional view of

* 'Some Physiological Factors in Illumination and Photometry,' Dr. Louis Bell; 'Light and Illumination,' Charles P. Steinmetz; 'Matters of Illumination which Affect the Eye,' Dr. Wendell Reber; 'Effect of Light upon the Eye,' Dr. H. H. Seabrook; 'Eyesight and Artificial Illumination,' Dr. John T. Krall; 'Artificial Illumination from a Physiological Point of View,' Dr. Myles Standish.

† Étude des principales sources de lumière au point de vue de l'hygiène de l'œil. MM. André Broca et F. Laporte. *Bulletin* of the Société Internationale des Électricians, Vol. VIII. (2nd series), No. 76.

bright sources or by subjecting the eye to sudden fluctuations of light.

4. *Intrinsic brightness* rather than the *distance* of the source from the eye is the principal cause for pupillary contraction.

5. The harmful effects are greatest in proportion to the decrease in the working illumination, and are considerably reduced under an illumination exceeding 2 foot-candles.

6. The different luminous sources may be classed with reference to producing pupillary contraction and after-images in the same order as their respective intensities.

In applying the knowledge to the laws of hygiene of the eye to the design of artificial illumination, the best criterion of the proper values of intrinsic brightness of the light source, as well as of other essential factors, is daylight.

From this point of view *diffusion* is the most important quality. Diffusion may be obtained in artificial illumination by enlarging the area or surface of the light source, by shading the source with diffusing globes or screens, or by concealing the source and utilizing the diffuse reflection of the surfaces which receive the direct light.

Whatever method may be applied in practice to secure improved diffusion and reduced intrinsic brightness of the artificial sources, it is most important to determine the values of intrinsic brightness which are both safe and advantageous to apply to the design of illumination.

The intrinsic brightness of a light source is the candle-power or *intensity of* the source divided by the *area* of the luminous surface. The intrinsic brightness of a small surface is the candle-power perpendicular to the surface divided by the area of the surface. Intrinsic brightness is stated, therefore, in candle-power per square inch, or in Hefners per square centimeter when metric units are employed.

Measurements of daylight-illumination taken by Basquin show a mean annual brightness for zenith sky in Chicago of 500 candles per square foot, or about 3·47 candles per square inch, with a range from 200 to 1,100 candles per square foot, according to the month and other conditions.

Under ordinary conditions the vertical brightness of the flux of light from the sky, direct sunlight excluded, though varying widely under different conditions, is not often more than one candle-power per square inch. Even such a comparatively low degree of brightness exposed to view affords discomfort to the eye. Shades and screens are depended upon to modify all but the most moderate natural brilliancy, so that with a satisfactory interior illumination the virtual intrinsic brightness of the flux of daylight through windows may be as low as 0·1 or even 0·01 candle-power per square inch.

Even an abnormally high illumination of 10 foot-candles on a white diffusing surface, such as white blotting paper, gives an intrinsic brightness of the surface very little more than 0·005 candle-power per square inch, neglecting absorption which would reduce the apparent brightness to 0·004 candle-power or less.

Compared with such figures the intrinsic brightness of all of the naked artificial luminous sources is enormously high, while the values secured in actual practice by the use of shades and diffuse reflecting surfaces are generally more than ten times as great.

A number of authorities regard 4 or 5 candle-power per square inch as safe and admissible and 1 or 2 candle-power good practice. While the use of even the lower of these values in artificial illuminations is questioned, it would result in a most pronounced improvement from the hygienic standpoint, and alleviate one of the principal causes of eye strain and fatigue.

Ordinary acid-frosted or sand-blasted incandescent carbon or metallized filament lamps have an intrinsic surface brightness of from 0·75 to 1·0 candle-power her square inch, and, when in the field of vision, such frosted lamps frequently produce a distressing effect, and considerably reduce the value of the effective illumination.

The author, therefore, considers that from 0·2 to 0·1 candle-power per square inch is none too low for the safest and best practice where artificial sources

must necessarily be placed in the constant or even occasional field of vision.

In the presence of a highly-illuminated field of view the iris diaphragm of the eye is "stopped" down almost to a minimum, and the direct effect of any light sources within the field of vision is correspondingly lessened. These conditions occur in practice where a room or space is almost uniformly illuminated by exposed lighting sources of high brilliancy, and there are neither dark surfaces, sharp contrasts, nor shadows which would require the eye to work with a larger pupillary aperture. Such conditions, while tending to reduce the deleterious effect of brilliant light sources, are not the most favourable for best vision. Working in such an environment it is not strange that a comparatively high intensity of illumination in foot-candles is frequently demanded, and the eye appears insatiable. From the standpoint of efficiency, therefore, as well as of hygiene, the conditions must favour a pupillary aperture which is sufficiently large to work the eye at its maximum sensibility. To accomplish this result the intensity of illumination should not only be moderate, in general from 1·5 to 4 foot-candles, but the intrinsic brightness of the sources should be reduced to 0·2 or a 0·1 candle-power per square inch; or else the sources must be completely excluded from the field of vision.

With a weak illumination, however, requiring the eye to work at or near the limit of opening of the pupillary aperture, the eye is extraordinarily sensitive to the direct light from sources of even moderate intrinsic brightness, and under such circumstances the actual apparent surface brightness of the source cannot be kept too low for safety.

The distance of the luminous source from the eye within the limits ordinarily found in interior illumination does not appear to be material, except in its relation to the position of the source and its inclusion or exclusion of the field of vision.

The preceding discussion has been confined to the direct effects and modification of the intrinsic brightness of luminous source, but it is evident that the same conditions will apply equally well to the reduction of the intrinsic brightness of all illuminated surfaces which become secondary sources of illuminations. Even with indirect illumination the ratio of brightness of the reflecting surfaces to that of the illuminated field may be excessive.

The foregoing data will have their principal application, however, in the design of globes and shades which are commonly employed to reduce the intrinsic brightness of exposed lighting sources. In arriving at the resultant intrinsic brightness it is necessary to refer to the spherical candle-power of the source, and to make allowance for the absorption by the glass which may vary between from 15 to 25 per cent for alabaster to 60 per cent or more for opal or porcelain glass. The absorption by ground glass will vary according to the process employed in roughing or sand blasting, but it will generally be between 20 and 40 per cent. The thickness as well as the quality of the glass will also have a marked influence upon the absorption. Moreover, the distribution of the light from this source will be modified by surrounding the lamp with an inclosing globe. The most perfect diffusion will be received by a ground opal glass, but at a sacrifice of from 40 to 60 per cent of the total light. The more transparent glasses, on the other hand, do not sufficiently diffuse the light from the source. In any event, however, it is important that the size of the diffusing globe or shade should be proportioned to the candle-power of the source, so that the reduction of intrinsic brightness will be approximately uniform.

Finally, the author points out that it is difficult to lay down hard and fast rules, and that much depends on the local conditions. However, the most essential point is to reduce the intrinsic brightness of all sources within the field of vision to not over 0·2 candle-power per square inch of diffusing surface.

Architecture and Illumination.

By Emile G. Perrot.

(Abstract of Paper read at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1908.)

The author remarks that the primary function of a building is to serve the practical uses of man.

If, however, architecture is considered in its real significance as being ornamental construction, one of the fine arts, and possessing in addition to its technical value, æsthetic and phonetic values—that is, beauty and power to tell a story—then illumination becomes only the handmaid of architecture, as are painting and sculpture.

Thus the relation of illumination and architecture presents a twofold aspect. According to Ruskin's view of architecture "we may live without her and worship without her, but we cannot remember without her," and we must recognize the ability of our architecture to transmit to posterity the true life and history of our time. Only thus will the highest function in the practice of the art have been fulfilled.

The architect's method of expression is by the use of the materials of construction, which must be so moulded and shaped as to give the appearance of solidity; the building must be solid and substantial in addition to being a thing of beauty. This effect is produced largely by means of shades and shadows; hence the knowledge of the "third dimension," as it is called, is necessary to the proper expression of a building. It is here that light plays a most important part in the bringing out of the details which characterize the work of the master architect. It was the understanding of the contour of details that made the Greeks surpass the Romans as artists, and is indicative of the perfection to which the Greek mind was developed as compared with that of the Roman. The study of the play of light and shade on the exterior of a building requires the highest kind of training for the successful outcome of an architectural composition; the effect of the building in strong sunlight being usually considered.

With the interior of the building, however, it is different. The effect of the strong sunlight no longer exists; a diffused or subdued light takes its place. Hence, the design of details for the interior of a building should not possess the same characteristics as are found on the exterior of buildings. Here again the skillful architect seizes his opportunity to display his talent by so modifying the details that they may be best brought out under the different light conditions.

The aspect of a building when viewed in daytime will be different from that at night with artificial illumination. Therefore, the architect should study the method of lighting in relation to its effect on the aspect of the design, in just the same manner as he does the effect of sunlight. This phase of the art of lighting, it must be confessed, has been very much neglected by the architect. It is to be hoped that greater care will be used, and more study put into the illumination of buildings, by our architects so that the result, when the building is completed, will be one in which no shortcoming from this cause will be visible.

Illumination may be divided into two parts—"necessary lighting," and "decorative lighting." Under the first head is included all methods of lighting which are used in buildings irrespective of the effect upon the architecture; in other words, the scientific application of the sources of light for the purposes of rendering possible the use of the building at night time.

The second division comprises that use of artificial lighting for the purposes of display, without any reference to the scientific or economic aspect. Of course the latter method of lighting also performs the function of the former.

The method of lighting outlined under the first heading is the one that has been employed in the majority of cases; in many instances it seriously counteracts the effects of the architecture by compelling the use of large and unsightly fixtures in locations ill adapted for them. This result is very noticeable

in large buildings whose prototypes are the monuments of ancient Rome and Greece, in which the use of elaborate chandeliers are unknown. However, lighting fixtures, if properly placed, and designed for the location, are one of the best means of adding to the furnishings of an apartment. The architect should design the fixtures for a building just as he designs the carving for a column capital or the bas-relief enrichment of a frieze, for the use of stock patterns for any feature of a building is reprehensible. On the other hand nothing is more striking in a building than a lighting fixture when in use at night time.

As a rule, the general practice heretofore has been for the architect either to make a selection from fixtures that are in stock or to entrust the designing of the fixtures to specialists in this line.

In many cases the architect is not consulted at all, the owner or committee arrogating this right to themselves, very frequently to save the architect's commission. However, in more important work the architect's influence on the selection of fixtures is felt more than ever, to the extent thus far that the architect even designs the hardware for the building, just as he would a stair-rail or iron-grille.

A very successful combination of architecture and illumination exists in the new Singer Building, New York. The lighting of the main entrance lobby is particularly striking by reason of the absence of electroliers, while the architect has made use of concealed lamps over a diffusing glass forming the centre of each vault; thus a flood of light emanates from the centre of each vault, bringing out very effectively the details of the building. The decorative or display lighting of the exterior of the building is effectively accomplished in the combined use of lamps to outline the architecture of the roof, and search lanterns to illumine the shafts of the high tower, bringing out, even in night time, the effect of the colour scheme. While the wisdom of the display on a building of this type, from an architectural standpoint, may be questioned, the author considers the scheme appropriate in the case of the lighting of pleasure buildings, such as are seen in the summer parks, such as the towers in Coney Island. The kaleidoscopic treatment of the designs in electric lamps is in keeping with the latter type of building, and the general use of lamps to outline the architecture and form part of the general treatment of the design is to be commended.

The author mentions the use of decorative lighting on a large scale in connexion with the Buffalo Exposition of 1901. On account of the nearness of the Exposition to Niagara Falls, he states, it was possible to produce effects on a large scale hardly possible when the cost of production is so much greater, and in this Exposition illumination served as the handmaid of architecture. The author considers, indeed, that for the perfect union of architecture and illumination the Buffalo Exposition has never been surpassed.

Mr. Perrot recommends that the Illuminating Engineering Society should materially help architects, by the publication of tables embodying results of tests and by giving data and formulas for the lighting of all types of buildings by various illuminants. Such pamphlets should contain examples of lighting schemes in existing buildings. The publication of such data would involve considerable labour and cost, but a committee of the Society could be appointed which would be able to accomplish this end, if the members consisted of those who had previously performed this service for the large manufacturing and lighting companies.

If buildings are to be properly lighted and made to embody the latest improvements, the architects should be kept in touch with all that is new and desirable for the purpose of effectively and economically lighting the buildings he designs, with the view of wedding together architecture and illumination, and thus leave to posterity the fullness of what has hitherto been but a faint effort of the proper union of the noblest of the fine arts, and the most useful of the sciences. This result, the author concludes, can be better accomplished through this Society than by any other means.

The Intensity of Natural Illumination Throughout the Day.

By Leonard J. Lewinson.

(Abstract of Paper read at the Second Annual Conference of the Illuminating Engineering Society, Oct. 5-6th, 1908.)

This paper deals primarily with the intensity of illumination produced by natural sources of light, such as the sun, moon, and stars, modified by the earth's atmosphere, and describes a series of experiments undertaken at different periods during the day.

A number of papers treating of daylight-illumination have appeared, but in all of them there is an almost entire absence of intensity-determinations—"foot-candle" values, which are of chief interest to illuminating engineers.

To the establishment of the best artificial conditions, a knowledge of natural conditions is essential. Men who deal with lighting problems are in need of data that can be applied in the design of artificial illumination. They should know the order of magnitude of the natural illumination intensity during the day, for which they endeavour to provide a substitute at night, or a reinforcement on dark days. They should appreciate the fluctuations in intensity to which natural illumination is subject—variations of greater extent than are met with in any artificial illumination.

A problem which is open to discussion, and which is of much importance, can be summed up in the question, "Why does the human eye, which is satisfied with an illumination of 2 foot-candles produced at night by an artificial source, require at least 20 foot-candles of daylight for ordinary reading purposes?" It is believed that studies of the kind considered in this paper will shed some light on this interesting question.

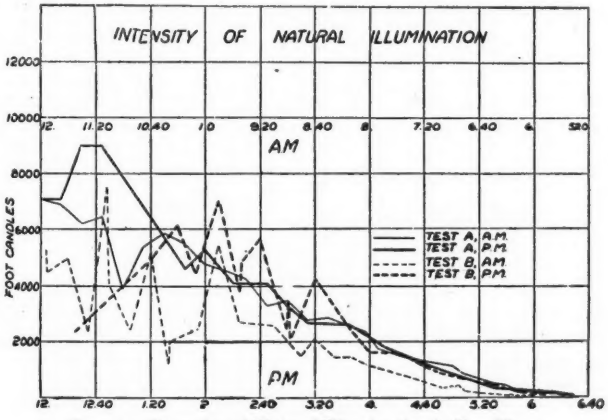


Fig. 1.—Intensity of Natural Illumination in Day Time.

Moonlight intensity is of particular interest in connexion with street-lighting. It has been the chief criterion, particularly in this country, and will probably remain so for years to come. In many towns, lighting plants are operated on a "moonlight schedule," the lamps being operated only when natural illumination is considered insufficient. "What is the illuminating value of moonlight?" "How does this in-

tensity vary?" These are questions which have long remained unanswered. Now, however, that engineers are approaching the problems of street-lighting from a scientific view-point, it is essential to know the foot-candle intensity of moonlight and skylight at night.

In these experiments two Sharp-Millar photometers,* equipped with miniature tungsten lamps were used, the experiments being conducted on the roof of the Electrical Testing Laboratories in New York City. There is practically no obstruction to sky-light. The roof of the adjoining building toward the west is only a few feet higher than the roof of the Laboratories. On the north side there are no buildings within 100 ft., and toward the east and south the space is practically open. When two photometers were used, the test plate of one was horizontal, and that of the second was turned so as to be normal to the direct light from the sun or moon. In certain tests, one photometer was used in making both sets of measurements.

With unvarying intensity and good colour value, a precision of approximately 1 per cent can be obtained with the photometers used in these tests. On account of the great colour differences and large variations in intensity which were encountered, the precision of the determinations was necessarily somewhat lower. For the purposes of this paper, however, the results attained may be considered as substantially correct.

TEST A.

24 HOURS' CONTINUOUS OBSERVATION.

Date: Sept. 9th and 10th, 1908.
Sun rises, Sept. 9th, 5.33 A.M.
Sun sets, Sept. 9th, 6.19 P.M.
Moon full, Sept. 10th, 7.45 A.M.

The sky during this test was clear, and practically cloudless throughout the entire twenty-four hours. There was a slight haze all day, except during the hours immediately preceding and following noon. This haze was slightly heavier in the early afternoon than during the morning. The temperature was about 61 degrees F. during the early morning hours, increasing to 73 degrees F. at noon, and steadily decreasing to 64 degrees F. at 9 P.M., after which it remained about constant until 3 A.M., Sept. 10th.

The results are expressed graphically in Figs. 1 and 2. Noon is taken as the starting point; the heavy, continuous line shows the illumination during the afternoon and evening of Sept. 9th, the scale of hours being shown

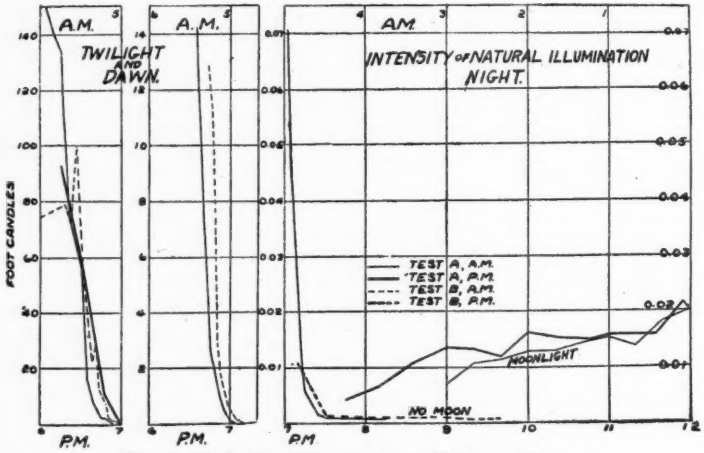


FIG. 2.—Intensity of Illumination at Night, no Moon.

* For description, see *Electrical World* and *Electrical Review*, Jan. 25, 1908.

at the bottom of the diagram. The thin, continuous line shows the illumination during the mornings of Sept. 9th and 10th, the scale of hours at the top of the diagram applying. It will be seen that the P.M. curves read from left to right, and the A.M. curves from right to left. Horizontal illumination intensities are shown in these diagrams, because the normal illumination values are available only during the periods when the sun and moon are visible.

Considering first the night illumination, one notes that the skylight value approximates 0·001 foot-candle, when the moon is not visible.

The rate of increase of illumination during the hour preceding sunrise is enormous, the intensity at 5.25 A.M., about seven minutes before sunrise,

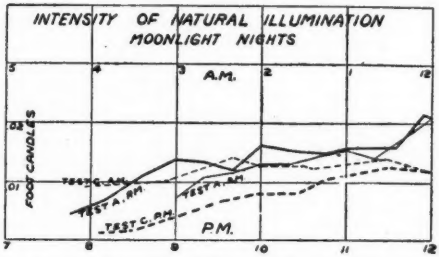


FIG. 3.—Intensity of Natural Illumination on Moonlight Night.

being approximately 10,000 times that at 4.25. During the hour after sunrise, the rate of increase is relatively small, the intensity at 6.38 A.M. being about eleven times that at 5.37 A.M.

A fair average figure for horizontal illumination produced by moonlight and skylight on this particular night is about 0·014 foot-candle, between 8.35 P.M. and 2.20 A.M. The "normal" illumination is about double the horizontal. The moonlight illumination is very much more constant during the night than is the sunlight during the day, probably due to the fact that on this occasion the moon did not rise as high in the sky as did the sun.

With noon as a starting point, working forward towards 6 o'clock in the afternoon, and backward toward 6 o'clock in the morning, the illumination curves correspond very closely, except during the hour immediately preceding and immediately following noon, where large fluctuations were noted, due to varying atmospheric conditions.

TEST B.

17 HOURS' CONTINUOUS OBSERVATION.

Date: Sept. 1, 1908,
Sun rises, 5.24 A.M.
Sun sets, 6.35 P.M.
No moon.

During the early morning there was a very heavy mist and the relative humidity was very high, decreasing from 98 per cent at 4.51 A.M. to 80 per cent at 10.20 A.M. From 10 o'clock to noon the per cent of relative humidity decreased more rapidly to about 48 per cent. The mist gradually disappeared, but the sky became overcast with irregular clouds.

Figs. 1 and 2 continue a graphical representation of the above results. Here, again, the rapid changes during the hour immediately preceding sunrise and the hour following sunset are noted. The fluctuations in intensity during the day are very marked, the ever-shifting mists during the morning and the heavy clouds which obscured the sun at times during the afternoon causing these variations. The average intensity during the afternoon, particularly after 1 o'clock, is higher than that in the morning, due to the disappearance of the heavy mists. Some of the intensities observed are considerably higher than the values at corresponding periods during the first test, probably due to the fact that the cloud formation at certain times caused an increase in the horizontal illumination intensity. This phenomenon has already been pointed out by Dr. Edward L. Nichols, in his paper on 'Daylight and Artificial Light,'* in which he shows a four-fold increase of illumination during eight minutes

* *Transactions* of the Illuminating Engineering Society, Vol. III., No. 5 (May, 1908). See also *Illuminating Engineer* (London), August.

preceding the obscuring of direct sunlight by the formation of a storm cloud.

Referring to Fig. 2, it will be seen that the skylight approximates 0.001 foot-candle after 7.30 P.M. There are slight variations from this value incident to the breaking up of the clouds after 9 o'clock.

It is of interest to note that at a few minutes before dawn and a few minutes after sunset the illumination is about 2 foot-candles; such an intensity produced by an artificial source, as stated before, is considered sufficient for reading purposes. In making the tests, however, it was found that when the natural illumination was 2 foot-candles, it was impossible to read the instruments without the aid of artificial light. On the clear day (Test A) the illumination was found to be 2 foot-candles at about 25 minutes before sunrise and 25 minutes after sunset. In Test B, when the sky was clouded or obscured by a heavy mist, this value was obtained at about 15 minutes before sunrise and 15 minutes after sunset.

TEST C.

10 HOURS' CONTINUOUS OBSERVATION.

Sun sets, 7.03 P.M., August 12th.
Sun rises, 5.04 A.M., August 13th.
Full moon, 12.15 A.M., August 12th.

During this test the percentage of relative humidity was very high, averaging about 90 during the night. Up to 9 o'clock there were light clouds in the sky. Between 9 and 10 P.M. the sky was cloudless. Subsequently a haze formed, causing the appearance of rings around the moon.

In Fig. 3 are shown the moonlight curves derived from the results of Tests A and C. The continuous line represents the intensity of the full moon during a clear September night. The broken line represents the intensity of the full moon during a night in August, the sky being almost cloudless, but somewhat hazy. During the August test, the intensity averages are somewhat lower than the September test, due probably to the haziness encountered during the earlier test.

Conclusions regarding natural illumination under conditions described are as follows:—

Certain cloud formations have the effect of increasing the intensity of illumination by diffusion. Other clouds act as absorbing media, and decrease the illumination intensity. Variations in intensity due to clouds, are often of a large order, and sometimes occur suddenly.

In the absence of clouds the rate of change of intensity between the hours of 8 A.M. and 4 P.M. is regular.

The rate of change of intensity during the hours of dawn and twilight is very high.

The skylight value at night, when there is no moon, is approximately .001 foot-candle.

The intensity of moonlight is about .014 foot-candle.

Daylight illumination varies in intensity from 2,000 to 8,000 foot-candles between the hours of 8 A.M. and 4 P.M.

It is hoped that the data herein presented may serve as an acceptable first step towards the establishment, on a quantitative basis, of the facts in regard to natural illumination. The author wishes to acknowledge his indebtedness to various persons, in particular Messrs. H. E. Allen and S. Ulmar, for valuable assistance in making the tests outlined in this paper.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

A Study of the Chief Sources of Light from the Standpoint of their Effect upon the Eye.

By MM. André Broca and F. Laporte.

(Abstracted from the *Bull. de la Soc. Int. des Électriciens*, June, 1908.)

In order to study illuminants differing in colour as widely as possible, the authors select for examination incandescent glow-lamps, arc-lamps, and mercury vapour-lamps; while it is almost impossible, theoretically, to compare the effect of hetero-chromatic lights, a similar study of the sources actually in use, may, from the practical standpoint, be considered feasible.

One well-known difficulty in hetero-chromatic photometry is the Purkinje effect, which, however, according to the work of Macé de Lepinay and Nicati, only becomes marked for wave-lengths below 0·517 μ, and for illumination below 0·7 lux. Again, it is recognized that visual acuity may be affected by wave-length irrespective of the intensity of illumination, and the authors therefore decided to investigate how far this and other effects influence the action of modern illuminants. Apart from this question of visual acuity, however, there are other problems, such as the production of fatigue in the eye, that also deserve consideration.

The investigations described by the authors fall into two sections:—

1. Those involving a comparison of visual acuity and speed of reading in the case of different illuminants; for this purpose the electric glow-lamp and the mercury-vapour lamp were selected as representing the widest range of colour likely to occur.

2. The study of the effect of receiving images of various bright sources on the retina; for this purpose it was deemed preferable to utilize also sources of great brilliancy, such as arc-lamps with or without globes.

Study of Visual Acuity.—In these experiments the authors employed a type of wedge photometer, the two sides of which were illuminated by an incandescent glow-lamp and mercury lamp respectively, and were brought, as nearly as could be, to equal brightness. A chart having type of various sizes, calculated to test visual acuity, was then inserted between the eye of the wedge, and the observer could thus compare the effect of both illuminants for equal brightness. Four observers were tested in this way.

TABLE I.

Source employed.	F.L.		R.J.		L.S.		A.G.	
	Illumination in Lux.	Visual Acuity.	Illumination in Lux.	Visual Acuity.	Illumination in Lux.	Visual Acuity.	Illumination in Lux.	Visual Acuity.
Mercury lamp	0·66	0·19	0·65	0·32	0·84	0·53	0·62	0·40
Glow lamp	**0·59**	**0·16**	**0·61**	**0·29**	**0·64**	**0·42**	**0·62**	**0·34**
Mercury lamp	1·87	0·45	1·63	0·55	2·40	0·84	1·85	0·76
Glow lamp	**1·57**	**0·42**	**1·63**	**0·51**	**1·71**	**0·76**	**1·44**	**0·69**
Mercury lamp	14·5	0·67	—	—	13·1	0·95	18·6	0·78
Glow lamp	**13·2**	**0·63**	—	—	**12·1**	**0·96**	**12·4**	**0·84**
Mercury lamp	16·6	0·71	19·1	0·85	19·7	1·27	20·5	0·84
Glow lamp	**19·2**	**0·625**	**20·15**	**0·95**	**20·2**	**1·40**	**19·8**	**0·88**
Mercury lamp	141	0·81	141	1·05	107	1·32	—	—
Glow lamp	**125·8**	**0·84**	**122**	**1·13**	**117**	**1·20**	—	—

As a result the authors find that, at all events when the range of illumination employed in practice is considered, no sensible difference between the two illuminants exist. The collected results are shown in Table I.

Probably if the illumination had been very much further reduced the introduction of the Purkinje effect would have led to an apparent greater visual acuity on

the part of one of the illuminants; but such orders of illumination hardly come within the scope of practical conditions.

Effect of Quality of Light on Speed of Reading.—In this experiment the same apparatus as that previously described was employed, but some running text displaced the acuteness of vision chart. For this purpose the type used in printing the *Bulletin* of the Bureau of Standards consisting of English words was employed. The distance at which it was found to be just possible to read the text was noted, and the type was set at a distance from the eye equal to 0·75 of this distance. In addition to the visual acuity, the time taken by each of three observers to read a line accurately was taken. In this way the results shown in Table II. were obtained.

From these results the authors draw the conclusion that the times of reading time of reading greater, but, during reading, fatigue soon sets in, and the time tends continually to increase; ultimately it becomes impossible to read at all.

The results described in Table II. are mainly in agreement with those undertaken with Sulzer (*Comptes Rendus*, 1903) on the time required to recognize isolated letters, though, of course, the conditions in reading print are somewhat different: our recognition being here assisted by the presence of neighbouring letters.

Leonard Weber, indeed, has stated that the speed of reading is directly proportional to the illumination, at least at feeble illuminations. This result, however, is essentially modified by the angle at which the type is viewed.

We ought to be able to specify the order of illumination needed in practice to enable reading to be carried out with the utmost speed and the least fatigue.

TABLE II.

(Illumination in lux. Time required to read a line by this illumination expressed in seconds.)

Source used.	F.L.			L.S.			A.G.		
	Lux.	Visual Acuity.	Time of Reading.	Lux.	Visual Acuity.	Time of Reading.	Lux.	Visual Acuity.	Time of Reading.
Mercury lamp	152	0·95	9·14	115	1·55	6·2	—	—	—
Glow lamp	**130**	**1·03**	**11·0**	**138**	**1·52**	**4·95**	—	—	—
Mercury lamp	16·4	0·97	9·14	15·3	1·27	5·18	—	—	—
Glow lamp	**16·2**	**0·82**	**9·5**	**16·2**	**1·31**	**7·8**	—	—	—
Mercury lamp	7·8	0·68	9·6	7·85	0·895	4·7	7·4	0·75	5·47
Glow lamp	**7·1**	**0·66**	**9·3**	**7·8**	**0·93**	**5**	**7·8**	**0·80**	**5·3**
Mercury lamp	3·5	0·57	10·2	3·5	0·71	5·2	3·8	0·64	5·8
Glow lamp	**3·9**	**0·55**	**10**	**3·9**	**0·77**	**5·9**	**4·4**	**0·68**	**11·6**
Mercury lamp	1·74	0·30	...	1·57	0·55	4·8	1·48	0·6	5·3
Glow lamp	**1·58**	**0·30**	...	**1·81**	**0·58**	**4·8**	**1·65**	**0·62**	**5·4**
Mercury lamp	0·51	0·26	...	0·46	0·22	5·1	0·5	0·33	5·6
Glow lamp	**0·50**	**0·28**	...	**0·59**	**0·32**	**4·25**	**0·51**	**0·36**	**5**

between illuminations at 0·5 to 150 lux can be regarded as practically constant. They state this conclusion formally by the following law:—

"When characters are presented to the eye, and are so arranged that they subtend an angle at the eye which is a certain given multiple of the limiting angle of distinct vision, the speed of reading is constant, whatever be the conditions of illumination, in the case of sources actually in practical use."

As will be seen from Fig. 1, however, the time of reading depends to some extent on the distance of the eye, approaching a limiting value when the latter becomes less than half the limiting angle of distinct vision.

When the limiting distance of distinct vision is reached, not only is the initial

From the standpoint of accommodation of the eyes it is recommended that a person with normal vision should not approach the book he is reading nearer than 0·35 metres, and the authors consider that an illumination is to be condemned that does not permit of ordinary print being distinguishable at a distance of 1·2–1·4 metres.

The whole question is of considerable practical importance. Doctors state that patients who return to them, complaining that their glasses are no longer strong enough, find that it is mainly in the evening that they experience fatigue. Now, in general, the illumination in the evening is far less than in the daytime, and the fact that his accommodation prevents him reading at the necessary one-quarter of the limited distance of distinct vision,

naturally leads to fatigue, and limits the amount of work he can turn out.

The short-sighted individual is not infrequently satisfied with an illumination too feeble for those with normal view, because he is able to accommodate with the book very close to the eyes. But before he reaches his nearest point of distinct vision he is usually exerting an injurious effort, and this, in conjunction with the effort of convergence on the part of both eyes, accounts for the number of progressive myopes, in many badly-lighted schools, that constitutes one of the curses of modern civilization. Electrical engineers cannot be too careful to provide adequate illumination in such cases.

For No. 11 an illumination of 30 lux suffices; for No. 9 and the *Journal* not even 100 lux enables the print to be read with ease. The conclusion from these figures can be drawn that the illumination should not fall below 30–40 lux. Recommendations on this point ought to be obligatory by law in schools, and also, as Javal has already insisted, the regulations forbidding the use of excessively fine print.

However, these investigations suggest that all practical sources of light stand on the same footing in this respect.

The Effect of Contractions of the Pupil-Aperture.—Alterations in diameter of the diameter of the pupil-orifice have a

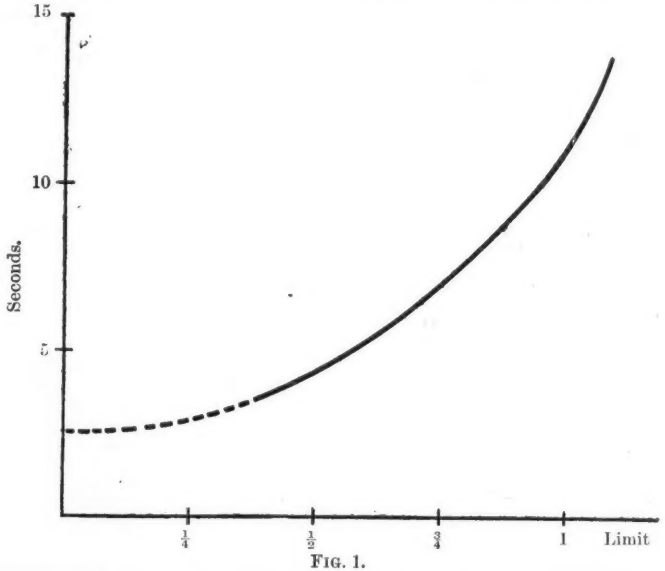


FIG. 1.

As an example of the effect of illumination on limiting distance of reading, the authors give the following table, referring to the type in the *Journal* and the *Bulletin* of the society :—

TABLE III.

Illumination in lux.	Limiting distance of reading.		
	Bull. No. 11.	Bull. No. 9.	"Journal."
1	80	70	75
2	105	85	85
10	145	130	125
30	160	140	145
100	180	145	145

marked influence on visual acuity. When the illumination of white paper is less than 10 lux, the diminution of visible acuity so caused helps to produce fatigue. On the other hand, the contraction of the iris with higher illumination assists acuteness of vision.

Apart from this, however, a light object in the field of view impedes vision by causing less bright objects to appear dark in comparison, while retinal adaptation to bright images causes the same effect (André Broca, *Comptes Rendus*, 1901).

Thus it *may* happen that, when we are looking at *brightly* illuminated paper, a very bright object in the field of view may actually increase visual acuity by

diminishing the pupil-aperture, and from this point of view might seem beneficial, were it not for the fatiguing effect of the retinal image. On the other hand, the gain in visual acuity in this way is trifling in comparison with the effect of fatigue. When the paper is *weakly* illuminated, of course, the visual acuity would also be greatly reduced.

As a result of a series of observations on the diameter of the pupil of five different observers, whose eyes are affected by a bright light coming within the field of view, the authors draw the conclusion that the contraction of the pupil-orifice is mainly due to the order of brilliancy of a source, and is not affected by its dimensions or by its colour. These experiments were carried out on tantalum, naked and enclosed arcs, Nernst-lamps, and mercury-vapour lamps.

The contraction of the pupil may be regarded as a natural defence against excessive brightness, each portion of the retina on which a bright image faces being capable of independent action.

The effect of pupil-diameter on the light admitted to the eye is shown by Table IV.

TABLE IV.

Conditions.	Pupillary Diameter	Fraction of illumination transmitted.
No source in field of view	12	1
Glow lamp or ordinary flame ...	8	0·43
Mercury arc	6·8	0·32
Arc with globe	6 to 7	0·25 to 0.34
Naked arc	5·7	0·225

The effect of such changes on visual acuity when the paper is illuminated with a *comparatively low* illumination can easily be understood. Thus, if we are looking at a paper illuminated by an intensity of 1 lux, the normal visual acuity of the unconstricted eye, about 8, will fall to 0·6, 0·5, and 0·45 respectively if a glow-lamp, a mercury-arc, or a naked arc-light are brought into the field of view.

In counting on these figures the authors remark that the intrinsic brilliancy of the naked arc is about 20,000 candles per square centimetre, while that of the tantalum lamp and mercury-vapour lamp, physiologically considered, approaches 2·4 and 1·8 candles per square centimetre respectively—the value for the tantalum lamp is obtained on the assumption that the image is to be spread out on the retina so as to occupy the space apparently enclosed within the outlines of the filament.

Yet the mercury lamp, in spite of its low intrinsic brilliancy, can cause a very considerable contraction, and the authors ascribe this, partially, to the fatiguing nature of the light emitted by it. But the authors reserve their opinion as to the effects of prolonged working under the light from this lamp, remarking that the medical profession have not recorded any cases of injury so caused.

The authors conclude this section by recommending that all lights should be kept out of the normal line of vision, and preferably to employ diffusing systems such as to exclude even the possibility of their being seen.

The Study of Retinal Images.—After looking straight at a bright object two distinct phenomena occur. If we subsequently look at a brightly illuminated surface the retinal fatigue causes us to see a *dark* image of the object previously observed, on a bright background.

Afterwards, if we retire into darkness and look at a dark surface, we see a luminous image, which gradually dies away, often changes colour, and sometimes returns after disappearance several times before finally vanishing. It is possible that this image is caused by some restoring process in the retina, and its duration may indicate the extent of fatigue.

The authors have attempted to study the effect of looking straight at various sources for a given length of time, by observing this duration of the image. When the duration of the impression —the time during which the eye was fastened on the bright source—was relatively long, it appeared that no very definite conclusion could be drawn. Thus, when the duration of impression was three seconds and ten seconds, the mercury lamp and the tantalum lamp led to apparently similar results—the duration of the image varying from 40 to 85 seconds. When the period of impression was only 0·5 seconds, however, more definite conclusions could be drawn, the mean durations of the residual image being :—

	Duration of Image.
Mercury arc... ...	33 seconds.
Tantalum lamp ...	35·5 ,,
Flame-arc with globe	43·5 ,,
Naked flame-arc ...	56·3 ,,

the lamps being thus arranged in order of intrinsic brilliancy. In any case, however, the fact that so permanent a residual image can be formed by only half a second's exposure is an additional indication that such sources ought to be kept out of the field of view.

The Public Lighting in Berlin by Means of High-Pressure Incandescent Gas Lamps.

By Prof. H. Drehschmidt.

(Paper read at the Annual Meeting of the Deutscher Verein von Gas- und Wasserfachmännern. Abstracted from the *Journal für Gasbeleuchtung*, No. 34, August 22nd, 1908.)

Good illumination is already a prime necessity in the streets of large towns, both from the point of view of safety and in the general interests of traffic; also as the traffic becomes greater the degree of illumination must be correspondingly increased.

In Berlin it has recently been realized, in consequence of the illumination in the Alexanderstrasse, that gas-lighting could still compete with electric for street-lighting. Yet the advent of the flame arc had been regarded by many as the final proof of the superiority of electric lighting. For instance the lighting of the Potsdamerplatz by four flame-arcs, and the square facing the Brandenburger Thor produced this impression.

The upright incandescent gaslight, even utilizing high-pressure gas, was disadvantageous in that much of its light was directed upwards; even the use of reflectors could only modify this bad quality, and at the expense of a certain loss of light by absorption. The inverted gaslight, however, has a much more saitisfactory curve of polar distribution of light, and some trials of inverted burners. at ordinary pressure, have recently been made in the Invalidenstrasse. More recently high-pressure gas been has used.

It was assumed that streets and squares through which heavy traffic passed would require lamps taking about 2·4 cubic metres (about 85 cubic feet) of gas per hour, and that those in the less busy streets would require half as much; each lamp was to be provided with two burners.

Originally trials were made with the Selas air-gas mixture, but it was subsequently found that equally efficient results could be obtained with compressed gas. Afterwards the firm of Ehrich & Graetz were invited to compete, and after about two years experiments some lamps were introduced into the streets.

A number of special precautions are necessary in order to secure the desired reliability. For instance, the burner, mixing-chamber, and top must be specially massive, in order to avoid overheating from the products of combustion, to which they are freely exposed. Again, the dimensions of the mixing chamber must be so selected as to secure the most favourable conditions when the desired consumption of 600 to 1,200 litres of gas are consumed. Special design is also necessary to render the lamps windproof,

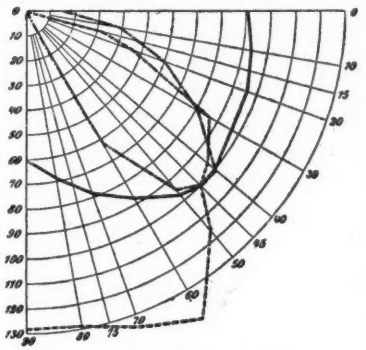


Fig. 1.—Distribution of Light.

——— High-Pressure Inverted Gas Lamps.
- - - - - - Flame Arc.
— · — · — Ordinary Arc (Vertical Colours).

and the method of leading away the products of combustion is here very material.

Considerable time was devoted to the selection and testing of a suitable mantle. In the case of high-pressure lamps the mantle, unlike that used with low-pressure, must bear up close upon the mouth of the burner, and the products of combustion are then forced through the mantle. Until recently double mantles were utilized, burnt off, and shaped upon a special apparatus. The highest illuminating power was secured by using such mantles, the light from the inner one piercing the meshes of the outer, so that their combined luminous effect was greater than that of a single mantle would have been.

Unfortunately the life of all such mantles was at first extremely short—as little as a quarter of an hour in some cases,

These difficulties were, however, eventually removed by a suitable design of mantle and burner, and the lamps were put into public use last Christmas.

The lamps containing two burners, each of which consumed 600 litres (21 cubic feet approximately), were satisfactory; but the globes of lamps consuming twice this amount of gas required frequent renewal. The lamps as a whole were similar in the two cases, only the burners and mantles being different, and it appeared that the latter were too long for the lanterns in which they were included. Subsequently the two 1,200 litre burners were replaced by three, each consuming 800 litres of gas, this change being made in the Königgrätzerstrasse and the Potsdamerstrasse. The illumination resulting was considered satisfactory, the three-mantle lights giving, in favourable instances, 0·65 litres per H.K. (about 40 candles per cubic foot); the two-burner lamps yielded only 0·75 litres per H.K. (35 candles per cubic foot); but the same close attention has not been paid to these lamps as to the three-burner variety. The distribution of light from the lamps is, however, of almost equal importance, and in this connexion the curves shown in Fig. 1, where the three-burner lamp is compared with a flame arc-lamp and an ordinary open arc-lamp, as regards distribution of light, are of interest. Apparently the inverted gas-light gives the greatest illumination in a horizontal direction, and the old white-arc the least. The first-named, therefore, would seem to be the best for lighting extended spaces, and the last-named the worst.

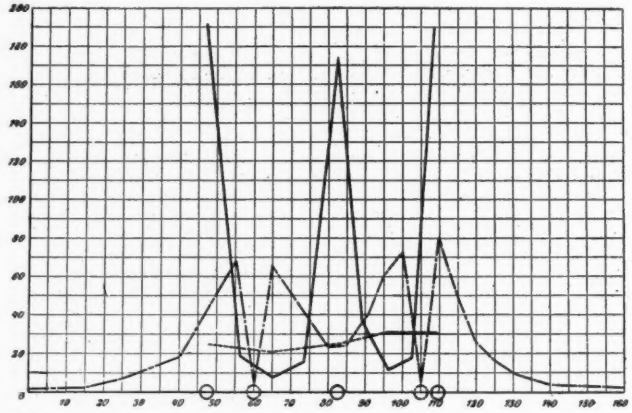


FIG. 2.—Horizontal Illumination by High-Pressure Inverted Burners in the Potsdamerstrasse.

——— ——— In the Line of the Lamps.
– – – – – – Middle of Roadway.
— — — — — — Flame Arc Lighting.

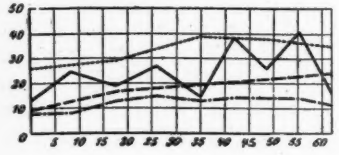


FIG. 3.—Illumination in a Vertical Plane.

—·—·— ——— In Line of Lamps.
····· – – – – – In Middle of Roadway.

In Fig. 2 are shown some curves illustrating the distribution of illumination, measured on a horizontal plane, in the Potsdamerplatz and the Potsdamerstrasse, which are lighted by flame-arcs and inverted incandescent burners respectively. Fig. 3 shows corresponding results for a vertical plane.

The author regards the vertical illumination in the streets as highly important, as facilitating the recognition of people, inscriptions on vehicles, placards, &c. The curves as a whole show that in both cases marked differences in the illumination occur, especially in the line of the lamps; in the middle of the road, however, the gas-lighting is very uniform. The vertical illumination in the Potsdamerstrasse is also both high and uniform throughout.

Recent Progress in Street Illumination in Berlin.

By Dr. L. Bloch.

Dr. L. Bloch sends us a recent report on the subject of the comparison of the various systems of street-lighting, which is of exceptional interest at the present moment. Want of space prevents us from publishing this article in full, but in what follows we propose to deal with the matter in abstract.

The author prefaces his description by remarking that the rapid developments in methods of lighting the main streets of Berlin since his experiments in the year 1905 (published in the *Journal für Gasbeleuchtung*, 1906, p. 90), when the illumination of Berlin was carried out mainly by high-pressure upright incandescent gaslights, and ordinary continuous current arc-lamps, invalidated old comparison and called for further study.

The upright high-pressure incandescent mantles were replaced by inverted mantles at ordinary pressure for the first time in the Invalidenstrasse in 1906 (see Drehschmidt, *Jour. f. Gasbeleuchtung*, 1906, p. 765), and although no very marked increase in the strength of illumination was achieved in this way, the actual cost was reduced.

In 1907 high-pressure inverted lighting was introduced in the Königgrätzerstrasse, and this method was soon extended to the majority of other streets in Berlin (see Drehschmidt, *Jour. f. Gasbeleuchtung*, 1908, p. 761).

Dr. Bloch describes the lighting in this street, which is 28·5 metres broad. The lamps were spaced 42 metres apart, at a height of 5·5 metres, each lamp consisting of two burners each consuming 1,200 litres of gas per hour; yet more recently these two burners have been replaced by three smaller ones, each consuming 800 litres per hour. The author gives the results of measurement of illumination in this street from which it would appear that the maximum horizontal illumination is 99 lux, the mean 18 lux, and the minimum 1·9 lux.

Similar results are given for the Potsdamerstrasse, the mean illumination being almost identical in the two cases, but the uniformity somewhat less favourable in the latter.

A comparison of the conditions in the Königgrätzerstrasse shows that the illumination has been much improved under the new system. This will be understood from the collected results in Table I., the actual mean horizontal illumination being increased nearly eleven times, and the consumption of gas per lux per 100 sq. metres being reduced by one half. There can be no doubt that the previous value of 1·6 lux was far too small for such a prominent thoroughfare. The author, however, points out a growing danger that, nowadays, main thoroughfares may be illuminated so brightly as to plunge the adjacent smaller streets into relative darkness, with the result that it is difficult to distinguish traffic, &c., coming down them. In the same way the ever-increasing illumination in public streets induces shopkeepers to accentuate *their* illumination, for the sake of contrast; this principle incautiously applied is liable to lead to undesirable dazzling effects.

The collected results in Table I. also show that the mean illumination in the Potsdamer and Königgrätzer Strasse is about 3·3 times as strong as in the Invaliden and Alexander Strasse, which was formerly the street most brilliantly illuminated by means of gas in Berlin.

The results may be summed up by remarking that the introduction of inverted gas-lighting has increased the available mean illumination, but also increased the ratio of maximum to minimum.

As regards electrical illumination, during the last few years the ordinary white carbon lamps have been replaced by flame-arcs with inclined carbons; certain initial difficulties having been overcome, there is now no doubt as to the practicability of the system, which has been utilized in the Potsdamer Platz, near the Brandenburger Thor, &c.

More recently, however, a new variety of "Alba" carbons has been brought out, which unite the merits both of flame-carbons and carbons of the ordinary variety. These carbons yield a pure white light, and can be utilized vertically. Owing to the great diameter of the carbons, they approximate to the same burning

Variety of Lamp.	Place.	m, by measurement, c, calculation.	Height of Lamp.	Distance between Lamps.	Width of Street.	Surface-Area of Street per Lamp Post.	Consumption per Lamp.	Consumption per 100 sq. m. of Surface. Area of Street.	Consumption for 1 Lux and 100 sq. m. Area.	Horizontal Illumination.			
										Mean.	Max.	Min.	Max, Min.
			mtrs.	mtrs.	mtrs.	squ. mtrs.	ltrs. p. hr.	ltrs. per hr.	ltrs. per hr.				
GASLIGHTING :													
Inverted Incandescent ...	Potsdamer Strasse	m	5·5	40	36·6	732	3×800	328	19	17·3	123	1·7	72
High Pressure Gaslighting	Königgrätzer Str.	m	5·5	42	28·5	600	2×1200	400	22	18·0	99	1·9	52
Upright Incandescent Gaslight ordinary Pressure	Königgrätzer Str.	c	3·5	28	28·5	400	2×125	62·5	39	1·6	11·1	0·25	44
Upright High Pressure Gaslight	Alexanderstrasse	m	5·7	42	21	441	2×600	272	52	5·2	18·9	0·8	23·5
	Königstrasse ...	m	5·7	42	20·5	431	2×1200	557	48	11·7	41	2·0	20·5
Inverted Gaslight, ordinary Pressure	Invalidenstrasse	m	4·5	28	17	238	4×114	192	35	5·5	58	0·6	97
ELECTRIC LIGHTING :													
Ordinary Arc Lamp with Pure Carbons	Friedrichstrasse	m	10	30	22	660	Watts 825	Watts 125	Watts 18·4	6·8	11·1	2·6	4·3
Flame-arc Lamps with "Alba" Carbons ...	Friedrichstrasse	m	10	30	22	660	825	125	6·9	18·2	31·2	6·6	4·7
	Potsdamer Strasse	c	5·5	40	36·6	732	825	112	4·9	23·1	132·3	2·0	66
	,, ,,	c	7	40	36·6	732	825	112	5·2	21·7	71·5	2·9	24·6
Intense Flame-arc lamp	Potsdamer Strasse	c	7	40	36·6	732	825	112	5·4	20·7	121·5	2·5	49
	,, ,,	m	18	45	—	3640	4×1100	120	6·5	18·8	82	1·3	63

Table showing the details of the illumination of various streets in Berlin by gas and electric lighting.

hours as in the case of ordinary carbons. On the other hand, the efficiency is very high, being given as 0·14 to 0·15 watts per mean hemispherical H.K., exclusive of the loss by absorption of globes and in the series resistance. Finally, the curve of distribution of light from such carbons is preferable to that of the older flame-arcs, which throw all the light immediately downwards, for purposes of street-lighting.

Sixteen ordinary continuous current arc-lamps in the Friedrichstrasse were equipped with these new carbons, and were experimented with during June of the present year. The lamps are suspended at a height of 10 metres, and yield a light of 3,100 H.K. (mean hemispherical) with opal glass globes. The horizontal illumination (measured as usual at a height of 1 metre from the ground) varied from 5·3 to 39·4 lux.

As will be seen from Table I., the mean illumination was increased as much as 2·7 times by the use of the new lamps. Moreover, on account of the great height of the lamps, and the advantageous shape of the polar curve of distribution, the uniformity of the illumination is materially improved. By comparison with the inverted high-pressure lighting we observe that the value of the mean horizontal illumination is approximately the same in each case; on the other hand, the *degree of uniformity* is very different.

This arises partially from the fact that the arc-lamps are 10 metres high and the gas lamps only 5·5 metres. But it is also dependent on the difference in the widths of the streets in the respective cases, and therefore the author proceeds to calculate the illumination of the Potsdamerstrasse, on the assumption that it is lighted by flame-arcs, and finds that a somewhat more uniform illumination than by gas, and a mean value 33 per cent higher, would be obtained. The vertical illumination would also be improved; even if the height of the lamps were increased to 7 metres, more favourable results both as regards intensity and uniformity of illumination would be obtained by electricity.

In the concluding portion of the article the author enters into a comparison of the running costs of both gas and electric systems. He sums up the situation by remarking that gaslighting has made great progress by the introduction of the inverted high-pressure light, but that electric lighting has likewise been enabled to hold its position by the use of intense flame-arcs, and, more recently, by the introduction and use of flame-arcs with the "Albo" carbons.

In cases in which high-pressure gas had begun to displace the old ordinary arc-lamps, the introduction of the newer lamps referred to above has once more enabled electric lighting to more than hold its own.

But it is as impossible as ever to contend that either of the illuminants is invariably the cheaper; each case must be considered on its merits, and depends on the local conditions.

Recent Progress in Arc-Lamps and Incandescent Glow-Lamps.

Prof. A. Blondel has sent us copies of his recent papers on the above subjects at the Marseilles International Electrical Congress. We regret that we are unable to make detailed reference to these interesting contributions in this number, but mean to do so shortly. The paper dealing with progress in incandescent glow-lamps contains an exceptionally complete resumé of recent patents on metallic filament lamps, while Prof. Blondel's second contribution discusses in detail recent developments in the theory of ionization and their application to the manufacture of flame and mineralized carbons.

Another Effect of Ultra-Violet Light.

An additional and hitherto unsuspected effect of the ultra-violet rays from a quartz-mercury lamp was mentioned by Dr. Schanz and Stockhausen in a recent article in *D. Graefe's Archiv für optahlmologie*. In this case Dr. Schanz was working in a room brightly illuminated by the quartz lamp, all *direct* rays being, however, screened. Nevertheless, Dr. Schanz, who had not previously worked under these conditions, was seized with such an unpleasant dizzy feeling in the head that he had to abandon all further work for the day.

It is also related that the same observer on another occasion experienced a most disagreeable feeling in the pit of the stomach, and a lack of breath. An engineer who was engaged in a works for the manufacture of electric lamps stated that this was a recognized experience, and that the workmen's position was therefore so chosen that the abdomen was protected from the direct rays of the lamp.

The Relative Merits of Compressed Gas and Compressed Air for Lighting.

An interesting discussion on this point has recently been raging in the gas journals in this country and in Germany. In the *Zeitschrift für Beleuchtungswesen* for May 20th appeared a communication from the laboratory of Dr. Lux, in which the merits of the system of compressed air were dwelt upon, and this has been followed by a correspondence in the columns of the *Journal für Gasbeleuchtung und Wasserversorgung* by those interested in both systems.

Dr. Lux points out that though it is, of course, incontestible that a great increase in efficiency has followed the adoption of high-pressure gas, yet there seems to be some misconception in the minds of many as to what, exactly, this improvement is due. According to the view referred to above, there is no special quality in compressed gas itself. The use of the pressure is only for the purpose of bringing the gas and air in the burner into intimate mixture in order that the most favourable conditions for rapid and complete combustion of the gas may prevail. The efficiency of an incandescent body depends mainly upon the flame temperature, and the maximum temperature is attained when the combustion of the gas takes place in the smallest imaginable period of time.

The use of high-pressure gas, therefore, serves merely to utilize the injector-action so as to secure intimate mixture. There are, however, practical limitations to the pressure that can be employed. A pressure of about 1 atmosphere is certainly about the utmost that can be regarded as reliable, while the systems of high-pressure gas-lighting in practical use do not utilize pressures higher than $\frac{1}{10}$ to $\frac{1}{5}$ of an atmosphere (*i.e.*, about 40 to 80 inches of water). The Salzenburg globe light, it is true, employed a pressure as high as 1·1 atmospheres, but this lamp, while yielding results of interest from the theoretical standpoint, can hardly be said to have achieved great practical success.

That compressed gas has no specific effect, and only acts by accentuating the injector action at the nozzle is shown by the fact that the actual pressure in the interior of the burner only reaches a few millimetres. On the other hand, it may legitimately be suggested that the use of compressed gas in order to put a body of air into motion and mix it with the gas is but an indirect and cumbrous method, and must involve the expenditure of a considerable amount of energy. Moreover, the loss of energy in overcoming the inertia of such a large volume of air results in but a small ultimate velocity of outflow of gas, and this is apt to lead to the production of too small a flame, and to a danger of the flame "striking back"—an effect that is particularly liable to take place in the case of compressed gas systems.

As an alternative and preferable method of producing the desired mixture of gas and air, therefore, the writer suggests that it is better to lead compressed air direct into the burner from separate pipes.

The use of compressed gas is open to other drawbacks. It is often contended that the arrangement is exceedingly simple, but in reality it is doubtful whether this can be considered to be the case. For one thing, the use of high-pressure gas entails the use of a special system of pipes, and it is particularly essential to attend carefully to the laying of these pipes so as to minimize the possibility of leakage, this being naturally of greater consequence than in the case of ordinary gas supply.

Again, in the case of buildings running on an ordinary lighting system, high-pressure gas is usually undesirable, and, when the public lighting is carried out by high-pressure, two distinct systems of piping become necessary. When pressure-gas is installed, separate meters are needed; in short, transformation from one system to another is not possible without altering entirely the nature of the service.

Another objection may be lodged against the use of pressure gas, namely, that any escape is liable to jeopardise the health of vegetation and trees lining the public streets.

In addition to the theoretical merit of facilitating the admixture of gas and air, the following advantages may, therefore, be claimed for pressure-air, as opposed to pressure-gas :—

1. Ordinary lamps and high-pressure-air lamps can be fed from the same gas-supply system.
2. When a change to compressed air is contemplated, it is unnecessary to alter the existing pipes in any way.
3. No special meters are necessary. Private and public lighting can be fed from the same gas mains.
4. In badly-ventilated rooms, pressure-air has the advantage of diminishing the consumption of air in the room, for the essential portion of the air feeding the burner is led in from without by the pressure-air pipes.
5. An escape of compressed air, unlike compressed gas, leads to no danger.

It must, of course, be recognized that a separate system of pipes is needed to feed burners with compressed air. Nevertheless, the system, besides possessing the advantage of being easily applicable to existing low-pressure installations, works out cheaper than a corresponding pressure-gas system. High-pressure air pipes can be economically constructed because an escape of air leads to no dangerous results.

Such are the main advantages claimed for pressure-air in the article mentioned, the merits of the method being illustrated by a description of the " Pharos " system.

A recent number of the *Journal für Gasbeleuchtung*, &c. (No. 24, 1908) contains a letter from the Pharos Co., who utilize both systems, but prefer pressure-air. The Pharos Co. also set forth most of the claims described above, namely, that compressed gas entails special meters, that the danger due to leakage is increased by its use, and that difficulties arise in the case of the salesman who at present utilizes a low-pressure system, but would like to have the benefit of high-pressure lamps outside the shop.

It is also pointed out that, in the case of compressed gas, the lighting and extinction of individual burners is attended by difficulties ; in particular, it is inconvenient to light up individual flames without interfering with the by-pass.

Also inconveniences arise in connexion with the measurement and rates of charging in the case of high-pressure gas, and in any case special rates, differing from those employed by low pressure, must be charged to consumers for high-pressure lamps as they care to instal.

This letter called forth two others in the same journal, arguing the merits of pressure-gas (No. 30, July 30th, 1908).

The *Köln Aktiengesellschaft für Gas und Elektricität* preface their arugments by pointing out that pressure-air installations were actually installed before pressure-gas had become common, but were eventually replaced by the latter.

It is also contended that the injector-action of the ordinary high-pressure arrangement is satisfactory for the purpose in view, and that the fall in pressure allowed in the burners must be considered in connexion with the wear and tear of mantles ; the wire-gauze employed with high-pressure burners not only serves the purpose of preventing the flame from lighting back, but also guards the mantles from being torn away. From this point of view pressure-air burners are open to objection, because they form long and narrow intense flames which penetrate the mantles, and may also injure the surrounding glass-globes.

The suggestion that the pressure-air system is a more economical method of mixing the air and gas is also contested. In the case of pressure-gas systems a pressure of 1000 to 1,300 mm. (*i.e.*, about 40 to 52 in.) is all that is necessary in order to secure the desired results. Now in the case of pressure-air a much larger bulk of air has to be set in motion and at a pressure of 1300 mm. (*i.e.*, about 52 in.) to secure similar results, and therefore the actual expenditure of energy can hardly be considered less than in the case of compressed gas.

It is also contended that pressure-air systems cannot be considered to be cheaper than those utilizing compressed gas. Also that :—

1. A meter for high-pressure gas is but little dearer than one of the ordinary variety, and even in the case of pressure-air a larger meter will be needed if a change in the conditions has to be made.
2. Extra installation work is necessary when pressure-air is installed just the same as in the case of pressure-gas. Moreover, in many cases the existing pipes answer for feeding high-pressure gas-lamps.
3. If the workmanship of an installation is satisfactory it matters little whether the pressure in the pipes is 40 mm. or 1300 (*i.e.*, 1·6 inches or 52). Accidents have caused no trouble in the case of the many high-pressure gas installations in actual use. Moreover, the pressure in the pipes during the night hours,

when no use of them is contemplated, is usually not maintained at a high value.

4. At the present time there are many perfectly satisfactory lighting and extinguishing devices for single flames on the market.
5. Any damage to high-pressure air lamps is just as serious in its consequences as in the case of pressure-gas lamps, and must be repaired with equal celerity. The effect of escaping high-pressure gas on trees in the streets can safely be ignored.

A letter from the *Millenium-Gesellschaft* in the same number covers similar ground. It is contended that high-pressure gas is in no way dangerous, that high-pressure meters, especially those of the dry variety, are easily and cheaply constructed, and that there is no inherent difficulty in making allowance for the compression of the gas and its consequent reduction in volume, when charging the consumer. It is, however, true that ordinary gas-meters can be used with compressed air, and this is the solitary advantage of systems of this nature.

Installations of high-pressure gas and high-pressure air systems entail the laying of practically identical amounts of pipe. All well-laid ordinary pipes, however, are tested up to a pressure of 1,500 mm. of water (approximately 60 in.), and are capable of taking gas at this pressure without the danger of leakage exceeding that of an ordinary gas-supply. Pressure-air pipes must be carefully looked after just like pressure-gas pipes. An escape of pressure-gas is immediately made evident by its odour. Pressure-air having no odour is more likely to be overlooked.

It is a mistake to suppose that pressure-air systems can usually be applied without any alteration to ordinary pipes. On the contrary, such pipes are too often hardly wide enough for existing conditions, and they are, therefore, unfitted to supply the higher quantities of gas that the introduction of high-pressure air high candle-power lamps would entail. It is also incorrect to suppose that high-pressure gas must necessarily lead to increased leakage. For instance, in Munich mains are regularly tested at a pressure of two atmospheres (780 in.), and no leakages are detected, as they certainly would be if they existed, at this high pressure.

The assumption that the pipe-supply of air alone feeds the burner with the necessary oxygen is unjustified. For in order to supply the correct proportions of 5·5 parts of air to 1 of gas, this would involve the use of exceedingly compressed air and very thick pipes.

Lastly, it is contended that the cost of high-pressure gas is in no respect higher than high-pressure air; that the extinction and lighting-up of high-pressure gas-burners is successfully accomplished in the streets of Berlin and elsewhere, and that there is ample evidence to show that existing high-pressure gas installations have no injurious effect upon vegetation.

References:—

Zeitschrift für Beleuchtungswesen, May 20. See also *Gas World*, May 30, 1908.

Journal für Gasbeleuchtung und Wasserversorgung, Nos. 24 and 30. See also *Gas World*, September 12, and *Journal of Gaslighting*, August 25, 1908.

The Theory of the Incandescent Mantle.

On Monday, October 12th, a lecture was delivered by Prof. Vivian Lewes before a meeting of the employees of the Gas, Light and Coke Co. The lecturer dealt briefly with the theory of the incandescent mantle, and expressed his adhesion to the catalytic theory as a basis of explanation of the luminosity of a suitable mixture of thorium and cerium.

It is stated that as many as 700 inspectors, foremen, and other workers in the employ of the company were present and evidently keenly appreciated Prof. Lewes's address. This furnishes one more indication of the great general interest in all aspects of lighting at the present day, and it is satisfactory to feel that the importance of educating employees in such subjects is becoming more and more appreciated.

New Method of Harbour-Lighting.

A novel system of harbour and coast lighting has recently been introduced in the United States, and some details of the experiments now taking place are given in a recent number of *The Progressive Age*.

The existing methods of using buoys, &c., are open to objection in several respects, and it is now proposed to utilize a submarine system of lighting, according to which electric lamps are installed beneath the surface of the water with the object of illuminating the rocks and other obstructions, and the various channels, thus simplifying the work of the pilot.

CORRESPONDENCE.

Absorption of Arc-Lamp Globes.

DEAR SIR,—Dr. Marchant's proposal to measure the light-absorption of globes by the difference between the light coming through a hole in the globe, and that of the surrounding surface, might indicate the very large loss of light he mentions as commonly occurring, but such a method is quite inaccurate.

The distribution of light is entirely altered by even a clear globe, the various portions of the globe deflecting and diffusing the light. Added to this source of error, the inside of all globes acts as a reflector, and light is reflected from the opposite side of the globe through the hole, in addition to that coming direct from the arc. The polar illumination curves with and without a globe are usually entirely different.

The alteration in the polar curve may be so great that if single measurements only are taken at a given angle, the light may be increased at the particular point measured; and the globe apparently add to instead of absorbing the light.

It is necessary in any absorption measurements to take the mean spherical candle-power.

Dr. Stine, from the mean of a large number of measurements, gives the absorption of clear globes at about 6 per cent, and frosted globes at about 11 per cent.

A number of measurements were also made by Messrs. Westerdale and Prentice, Proc. I.E.E., March 14th, 1906. The absorption given in all these measurements correspond closely with Prof. Morris's results.

Unfortunately I cannot entirely agree with Prof. Morris's method of measuring the efficiency of an arc-lamp globe by an incandescent lamp. Prof. Morris does not state if the mean spherical candle-power was taken, although the figures he gives indicate that this was done, but even then the apparent absorption by the globe apart from the lamp and reflector might be misleading. The distribution of light will be altered, and absorption or blocking of the light by a reflector and the lamp mechanism may give very different results.

The enclosed lamp was also rather handicapped by allowance having been made for one globe only. They certainly cannot be operated commercially without their globes, but neither can the ordinary open flame arc, without in either case excessive consumption of the carbon taking place and the additional reasons that Prof. Morris gives.

I think a method giving sufficient accuracy for all commercial needs would be the measurement of the loss of mean spherical candle-power given by a standard incandescent electric lamp when placed in the position usually occupied by the arc in the arc-lamp, the lamp being complete with globes, case, reflector, &c., in position. The difference in absorption due to the different spectra of an incandescent lamp and an arc-lamp may be disregarded with new globes.

Modern arc-globes when new are colourless, and although I have examined many with the spectroscope, I have found no appreciable selective absorption by either clear or opal globes.

Arc-lamp globes that have been long in use will sometimes turn to a yellowish tint, and dirt, either from the arc or ordinary town atmosphere, may absorb almost any percentage of light, unless the globes are cleaned when recarboning the lamp.

As a matter of practice I have long held that 20 per cent should be an outside limit of absorption for a globe of good glass, and have found little difficulty in obtaining glass well within this figure, although sufficiently opaque to give good diffusion.

After all, the actual amount of light coming from the lamp gives the figure of merit of the lamp, and we are greatly indebted to Prof. Morris for such an accurate and complete set of figures on modern lamps.

I remain, sir,

Yours very truly,

A. DENMAN JONES.

Some Exhibits at the Ideal Home Exhibition.

THE IDEAL HOME EXHIBITION naturally afforded an excellent opportunity of displaying different systems of lighting, and it is interesting to observe that not a few of the firms represented make a point of insisting that good illumination is not a luxury, but a necessity, and, in fact, as essential a characteristic of an ideal home as good furniture or anything else.

One feature of the lighting display was the number of makers of petrol-air apparatus that exhibited. Thus the Praed Patent Safety Gas Light Co. and the De Laitte Co., to both of whom we have referred previously, occupy adjacent stalls. Among other exhibitors we note: The National Air Gas Co., The Bens Gas Co., The "Litz" System, The Centenary Air-Gas Co., Cox's Non-Explosive Air-Gas System, The "Loco" Vapour-Gas Machine Co., "Aerogen Gas" (Messrs. Strode & Co.), &c.

The public has therefore ample opportunity to compare the merits of various systems of air-gas manufacture, and the number of systems now on the market would seem to indicate the existence of a wide field for such independent generating types of lighting.

In all cases the cheapness of air-gas is dwelt upon; for instance, the cost per 1,000 candle hours of the "Loco" and other illuminants is said to work out as follows: acetylene, 1*s.* 3*d.*; electric incandescent, 1*s.* 2*d.*; flat flame coal-gas, 1*s.*; duplex oil lamp, 7½*d.*; incandescent coal-gas, 2½*d.*; and "Loco" gas, 1¾*d.* In the same way the "Litz" machine is said to produce 1,000 candle hours at 1½*d.*, and the cost is generally stated by other exhibitors to be between one penny and twopence. At the same time it is pointed out that the air-gas generated is non-explosive, and non-poisonous, and some claim that no dangerous rays are present in the spectrum. According to one firm their system "is not dangerous like acetylene and electricity."

On the other hand, the claims of acetylene for country districts, where gas and electricity are not available, are represented by the Rural Districts Gaslight Company, who exhibit a complete acetylene installation.

Another illuminant on exhibition, available for use in country districts, was the "Petrolite" lamp, the chief recommendations of which are claimed to be that it cannot explode or take fire, and if overturned goes out; in addition it can be used in conjunction with incandescent mantles, and may therefore yield a high candle-power, but yet is independent of any generator, and is perfectly transportable, merely utilizing the petroleum in the reservoir of the lamp.

Among other miscellaneous gas exhibits we may mention the "Vulcan," Southwark, and other mantles and fittings exhibited by S. P. Catterson & Sons, the "Eureka" mantle, and the "Telephos" patent distance gas lighter which, it is claimed, enables gas to be turned off and on at a distance with the same convenience as electric light. In the electrical section mention may be made of the exhibit of fittings and electrical heating devices of Messrs. Rashleigh, Phipps & Co. and the Bryant Trading Syndicate, who claim to sell an entirely British-made metallic filament lamp which, by the way, is listed for pressures up to 250 volts.

The Calux Electric Co. also exhibit their "Solium" metallic filament lamp, which is stated to be capable of burning in any position, and this, too, is listed for pressures up to 260 volts. Electric heating apparatus was also exhibited.

Finally mention may be made of the "Tredegar" electric fittings, the special feature of which is that the lamp is mounted and suspended from an ornamental wooden bracket.

One of the chief impressions given by the exhibition is the importance now attached to illumination in the home, and the recognition that good lighting is absolutely essential. Exhibitions in which the public have an opportunity of contrasting different methods of lighting, and comparing the statements on behalf of different illuminants, have a distinct educational value.

Review of the Technical Press.

THIS month it is again necessary to draw attention to the immense amount of matter dealing with photometry and illumination that has been published in Europe and the United States—far more than could possibly be adequately dealt with in the pages that can be allotted to this review. Last month a variety of papers were published in the special number of *The Electrical Review* and *Electrical World* of New York. On this occasion special attention is merited by the series of eighteen papers read before the Second Annual Convention of the Illuminating Engineering Society recently held in Philadelphia.

PHOTOMETRY AND STANDARDS OF LIGHT.

Dr. A. C. Humphreys presents a very important report of the results of conferences of the committees of the Illuminating Engineering Society, the American Institution of Electrical Engineers, and the Institution of Electrical Engineers for the purpose of coming to agreement on the subject of A NATIONAL UNIT OF LIGHT. It appears that the units employed by the gas and electric industries in the United States, though both nominally derived from the British standard candle, actually differ by about 4 per cent.

It is therefore proposed to adopt a value for the national unit midway between these two, and it is expected that the coming international unit will fall within 1 per cent of this value.

A paper by **Dr. A. H. Elliott** deals with the use of OIL-LAMPS AS PHOTOMETRIC STANDARDS. He has found that very few data as to the constancy of petroleum flames are available, and therefore describes a series of tests on the subject with, on the whole, favourable results.

Dr. Clayton Sharp and **Mr. P. S. Miller** describe some experiments on the INTEGRATING GLOBE-PHOTOMETER of Ulbricht—a subject that has hitherto been almost exclusively treated in Germany. The authors used a number of globes of different sizes, including some small ones which served for the testing of glow-lamps. In this connexion they comment on the convenience of this method which avoids the troubles attending rotation of the lamp, and can easily be so arranged as to be employed in an undarkened room. They also describe a set of experiments carried out with the object of investigating the errors that can arise from the presence of screens and other foreign objects within the globe.

Dr. H. E. Ives describes the use of his form of "COLOUR-METER" IN ILLUMINATING ENGINEERING, and gives the results of a number of actual tests on the effect of various illuminants.

C. W. Waidner and **G. K. Burgess** contribute an interesting note to *The Electrical World* (Sept. 19th) on THE PRIMARY STANDARD OF LIGHT. After reviewing the flame and other possible standards they turn to the incandescent platinum type of Violle. The light from such a source depends upon three factors, the area of surface, the temperature, and the nature of the surface of the platinum. The last two quantities are the most difficult to maintain accurately constant. Special care is needed to eliminate changes in the radiating nature of the surface. The authors, therefore, suggest that it would be preferable to use a truly black surface such as could be obtained by the Reichsanstalt method. The intensity per square centimetre of such a surface, at the temperature of melting platinum, would be about 88 Hefner, and this value could be depended upon provided the temperature is maintained at a constant value.

A recent number of *The Journal of Gas Lighting* contains a description of some photometrical apparatus exhibited at the Manchester exhibition. This includes a description of the BENCH AND ROTATING LAMP-HOLDER used at the **National Physical Laboratory** and a new form of SIMMANCE - ABADY STREET-PHOTOMETER. An ingenious method of varying the intensity of the light is employed. A glow-lamp, let into a tube, illuminates the whitened interior of a hollow sphere so as to produce perfect diffusion. The amount of light emerging from this sphere and striking the photometer screen is regulated by using an adjustable aperture.

Recent numbers of the *Journal für Gasbeleuchtung* contain a reprint of the recent paper by **Paulus** on the PHOTOMETRY OF METALLIC FILAMENT LAMPS, and a report of an interesting discussion (arising therefrom) on the question of applying the standard specification to them. The *Zeitschrift für Beleuchtungswesen* for Oct. 10th prints a synopsis of the RULES OF THE VERBAND DEUTSCHER ELEKTROTECHNIKER, relating to the Photometry of arc-lamps.

ILLUMINATION.

The papers that have appeared on the subject of illumination are too nume-

rous to receive anything but very brief notice. The PRESIDENTIAL ADDRESS of **Dr. Louis Bell** at the Convention, dealt mainly with STREET LIGHTING. In the course of his remarks Dr. Bell insisted upon the necessity for taking due account of the purpose for which each illuminated street was intended, and not aiming at a uniform illumination all over the town, as was sometimes done in the United States. He also expressed himself in favour of the method of measurement, with a horizontal screen, mainly employed in Europe, and criticized the so-called "moonlight-schedule," as applied to street lighting.

A very valuable and exhaustive paper by **L. B. Marks**, before the Convention, described the system of illumination adopted in the Carnegie libraries of New York. The paper, containing, as it does, a full record of the lamps employed and their exact position, and the considerations on which the various plans of lighting were adopted, should serve as a standard reference to those interested in the lighting of libraries.

Several articles and papers from the pen of **C. Hering** have appeared. These deal with the FUNDAMENTAL UNITS AND QUANTITIES OF ILLUMINATING ENGINEERING, the paper before the Convention containing a comprehensive summary of the different formulæ involved. The author criticizes many of our existing methods of expressing photometrical quantities, and we may expect that some time must elapse ere these quantities and the scientific ideas utilized in illuminating engineering have become sufficiently familiar to be put upon a truly scientific basis.

In this connexion it is interesting to observe how the idea of "FLUX OF LIGHT," at one time a little understood scientific conception, is gaining ground. For instance a paper by **J. R. Cravath** and **V. R. Lansingh** before the Convention discusses the application of this quantity to practical problems in a very lucid manner, the authors arguing that in very many cases the introduction of the idea leads easily to an approximate prediction of the illumination over a given space, and avoids much needless elaboration of detail.

Among other papers before the Convention mention may be made of the series of experiments on DAYLIGHT ILLUMINATION by **L. J. Lewinson,** some experiments on the REFLECTING QUALITIES OF WALLS AND CEILINGS, by **V. R. Lansingh** and **T. W. Rolph,** and a paper on ARCHITECTURE AND ILLUMINATION by **E. G. Perrot.** The latter contains a suggestion that the Illuminating Engineering Society should undertake the preparation of standard data on illuminating matters in order to assist those in both professions.

A recent number of the *Journal für Gasbeleuchtung* contains a continuation of an interesting article by **Niemann** and **Du Bois** dealing with the HISTORY OF ARTIFICIAL ILLUMINATION; the authors now deal with a period up to the middle of the nineteenth century, and describe the early efforts to manufacture candles and oil lamps.

In the September number of *Annalen der Elektrotechnik* is to be found a reference to some work with a SELENIUM RECORDING APPARATUS, by the aid of which a chart of the VARIATION IN THE DAYLIGHT INTENSITY DURING A TOTAL SOLAR ECLIPSE was obtained. The value of selenium for *comparative* measurements of this description deserves special attention now that so much more is known about the preparation of this material. Such apparatus seems particularly adapted to recording purposes on account of its simplicity, and it seems possible that it might be applied with success to the study of conditions of illumination in schools, &c.

ELECTRIC LIGHTING.

Two very valuable contributions at the Marseilles Electrical Congress by **Prof. Blondel** deserve special mention. These two papers contain a comprehensive summary of recent progress in the fields of ELECTRIC ARC- AND GLOW-LAMP LIGHTING. The résumé of recent patents in metallic lamp manufacture in the latter paper is unusually up to date and complete, and the same may be said of the treatment of flame and mineralized carbons.

F. E. Cady's paper before the Convention of the Illuminating Engineering Society dealt with the CONNEXION BETWEEN P.D. AND LIGHT FROM INCANDESCENT ELECTRIC LAMPS. Besides detailing the results of original work carried out at the Bureau of Standards, the paper contains a useful collection of references to this particular subject. The chief result stated by the author is that the so-called constant k in the formula: Change in C.P. = Const. $\times$ (Change in C.P.)^k is not really constant but a function of the efficiency at which the lamp is working.

Another paper before the Convention by **J. R. Strong** deals with STRUCTURAL DIFFICULTIES IN INSTALLATION WORK. The paper advocates the locating of outlets in such a way as to enable an existing system of lighting to be modified if the furniture in a room is rearranged or the conditions are otherwise altered;

though this subject is of interest to those connected with all systems of lighting, the author deals mainly with the electrical aspects of the problem, and therefore the paper is classed in this section.

The *E.T.Z.* for Oct. 8th contains a paper by **R. Hopfelt,** recently read before the German Institution of Electrical Engineers, on a NEW FORM OF MERCURY-CARBON INCANDESCENT LAMP. This lamp was briefly described by B. Duschnitz in *The Illuminating Engineer* of August. The essential characteristic of it lies in surrounding a carbon filament, run at an exceptionally high efficiency, with mercury vapour, which, it is claimed, hinders the volatilization of the carbon, and so enables the filament to be run at a higher temperature than would be possible in an ordinary vacuum.

Mention may be made of two serial articles which deal comprehensively with recent patents and developments in incandescent and arc lighting by **B. Duschnitz** and **I. Ladoff** respectively. A third article on similar lines in the *Zeitschrift für Beleuchtungswesen* is concerned with the subject of arc-lamp mechanisms.

GAS, OIL, AND ACETYLENE LIGHTING.

Two of the papers before the Conventoin dealt with gas lighting. That by **T. J. Litle** was mainly devoted to METHODS OF AUTOMATIC IGNITION, including the electrical "jump-spark" method; one interesting development described by the author, however, consisted in a mantle mounted permanently within the small mica chimney, both being supplied as one unit.

E. N. Wrightington summarized the methods of STREET-LIGHTING IN EUROPE from the American point of view. The author was much struck by the development of high-pressure gas lighting, particularly the use of small units spaced close together. He remarks on one noticeable feature of European streets as compared with American ones. In America street-lighting from the recognized sources in main thoroughfares is often hardly necessary on account of the contribution from the many illuminated signs, shop-windows, &c., that line the street; in Europe, on the other hand, illuminated signs have not the vogue that they have attained in America, and in some cases the shops are closed and the shutters up at a relatively early hour in the evening. The method of street lighting provided by the authorities is therefore of greater consequence, and higher units are usually employed.

Prof. Vivian Lewes recently delivered a lecture at the Gas, Light and Coke Company's offices in London. He gave a summary of the present state of 'THEORIES OF THE ACTION OF THE INCANDESCENT MANTLE,' and expressed his adherence to the catalytic theory. An interesting point brought out by him was the high heat-radiating qualities of Cerium. In consequence of this property, if the Cerium in a mantle is increased above the desirable percentage its efficiency is decreased by the falling temperature arising from increased radiation. Prof. Lewes seems to have entertained the idea that this property might be utilized in heating apparatus. He found, however, that Cerium apparently only exhibits this quality when finely divided, and not when used in masses.

Recent numbers of the *Zeitschrift für Beleuchtungswesen* again contain a series of notices of new methods of utilizng liquids in incandescent lamps; recent numbers of *The Journal für Gasbeleuchtung* contain a brief discussion (abstracted) of methods of kindling and extinguishing the lamps in railway carriages, and a protest against the suggested tax on gas in Germany.

List of References:—

PHOTOMETRY AND STANDARDS OF LIGHT.

Elliott, Dr. A. H. Illuminating Value of Petroleum Oils (Sec. Ann. Conv. I. E. S.).
Humphreys, A. C. Report of Committee on Nomenclature and Standards (Sec. Ann. Conv. I.E.S.).
Ives, H. E. The Ives Colorimeter in Illuminating Engineering (Sec. Ann. Conv. I. E. S.).
Paulus, C. Vergleich der verschiedenen technischen Methoden zur Bestimmung der mittleren Horizontallichtstärke von Metallfadenlampen (J. f. G., Oct. 3).
Sharp, C. H., and Millar, P. S. The Integrating Sphere in Industrial Photometry (Sec. Ann. Conv. I. E. S.).
Waidner, C. W., and Burgess, G. K. Note on the Primary Standard of Light (*Elec. World*, N.Y., Sept. 19).
New Photometers and a Colorimeter (J. G. L., Oct. 6).
Normalien für Bogenlampen, aufgestellt vom Verbande Deutscher Elektrotechniker *Z. f. B.*, Oct. 10).
Ueber die Photometrierung und die technischen Lieferungsbedingungen von Metallfadenlampen (J. f. G., Oct. 3).

ILLUMINATION.

Bell, Dr. Louis. Presidential Address (Sec. Ann. Conv. I. E. S.).
Cravath, J. R., and Lansingh, V. R. The Calculation of Illumination by the Flux of Light Method (Sec. Ann. Conv. I. E. S.).

Editorials. The Symbolism of Light.....The Second Annual Convention of the Illuminating Engineering Society.....The Illuminating Engineer as an Architectural Critic, &c (*Illum. Engineer*, N.Y., Sept.).
The Illuminating Engineer (*Elec. Rev.*, Oct. 15).
A New Departure in Illuminating Engineering (*Elec. Rev.*, N.Y., Sept. 26).
The Future of the Tungsten Lamp.....The Primary Standard of Light.....The Relations of the Measures of Light and Power (*Elec. World*, N.Y., Sept. 19).
Eshleman, C. L. Developments in Ornamental and Boulevard-Lighting (*Illum. Engineer*, N.Y., Sept.).
Hering, C. Calculating and Comparing Lights from Various Sources (Sec. Ann. Conv. I. E. S.).
On the Relations of the Measures of Light and Power (*Elec. World*, N.Y., Sept. 19).
Simplifying Some of the Calculations of Light (*Elec. World*, N.Y., Sept. 26).
Lansingh, V. R., and Rolph, T. W. Experiments on Reflection from Ceiling, Walls and Floor (Sec. Ann. Conv. I. E. S.).
Lewinson, L. J. Intensity of Natural Illumination throughout the Day (Sec. Ann. Conv. I. E. S.).
Marks, L. B. Design of the Illumination of the New York Carnegie Libraries (Sec. Ann. Conv. I. E. S.).
Niemann and Du Bois. Zur Geschichte des Beleuchtungswesens (J. f. G., Oct. 17).
Perrot, E. G. Architecture and Illumination (Sec. Ann. Conv. I. E. S.).
Thurston Owens, H. Street-lighting Fixtures, Gas and Electric (Sec. Ann. Conv. I. E. S.).
Williams, G. Outline-lighting and the Central Station (*Illum. Engineer*, N.Y., Sept.).
Wohlauer, A. A. Engineering Problems in Illumination (Sec. Ann. Conv. I. E. S.).
Illuminating Engineering and the Central Station (*Illum. Engineer*, N.Y., Sept.).
Illuminating Engineering in America (J. G. L., Oct. 20).
Die Intensität des Tageslichtes (*Ann. der Elektrotechnik*, Sept., p. 369).
Modern Light-Shades (*Am. Gas Light Jour.* (Oct. 12).

ELECTRIC LIGHTING.

Bainville, A. Nouveaux Filaments Electriques (*l'Electricien*, Oct. 10).
Bloch, L. Ueber neuere elektrische Lichtquellen (*J. f. G.*, Sept. 26).
Blondel, A. Les Progrès de l'Incandescence Electrique ; Progrès des Lampes à Arc Electrique. (Two papers read at the Marseilles Electrical Congress.)
Cady, F. E. The Relation between Candle-power and Voltage of different types of Incandescent Lamps (Sec. Ann. Conv. I.E.S.).
Cateaux, J. L. Auto-transformers for Electric Lamps (*Elec. Review*, Oct. 16).
Duschnitz, B. Metallische Leuchtfäden und Metallfadenlampen in der Fabrikation und in der Praxis (*Elek. Anz.*, Oct. 15).
Editorial. Street-lighting Contracts and the Tungsten Lamp (*Elec. Rev.*, N.Y., Sept. 19).
Hoadley, E. E. The Present Position of Arc lamps and Arc lighting (*Elec. Rev*, Oct. 15).
Hopfelt, R. Eine neue Kohlenfaden-Quecksilberlampe (*E. T. Z.*, Oct. 8, 1908).
Ladoff, I. Recent Progress in the Voltaic Arc (*Illuminating Engineer*, N.Y., Sept.).
Mollenkopf and Remané. Betriebskosten kleiner Bogenlampen und hochkerziger Osramlampen (*E. T. Z.*, Oct. 1, Correspondence).
Strong, J. R. Structural Difficulties in Installation Work (Sec. Ann. Conv., I. E. S.).
Davy Arc Lamps (*Elec. Engineering*, Oct. 1).
Fittings at new Holborn Borough Council Office (*Elec. Engineering*, Oct. 8).
Public Lighting by Incandescent Lamps (*Elec. Review*, Oct. 9).
Tungsten and Nernst Incandescent Lamps (*Elec. World*, N.Y., Oct. 3).
Die neueren Bogenlampen (*Z. f. B.*, September 20 and 30).
Neue Lichtpausapparat (*E. T. Z.*, Oct. 8, *Elek. Anz.*, Oct. 4).

GAS, OIL, AND ACETYLENE LIGHTING.

Litle, T. J. Modern Gaslighting Conveniences (Sec. Ann. Conv. I. E. S.).
Marshall, F. D. A New and Improved Method of Lighting Railway Carriages by Liquified Oil-Gas (Blau Gas). (*G. W.*, Oct. 3).
Morris, J. T. High-power Gas and Electric Arc-lamps (*G. W.*, Oct. 17).
Wrightington, E. N. Street-lighting with Gas in Europe (Sec. Ann. Conv. I. E. S.).
A Lamp for Florists (*J. G. L.*, Oct. 6).
High Pressure Gas for Distribution (*G. W.*, Oct. 17).
The Chipperfield Self-Compressing Lamp (*J. G. L.*, Sept. 29).
Night Views at the Franco-British Exhibition (*J. G. L.*, Sept. 29).
Lampe für flüssige Brennstoffe (*Z. f. Bel.*, Oct. 10).
Prof. Lewes on the Incandescent Mantle (*J. G. L.*, Oct. 20, *G. W.*, Oct. 17).
Comparison du Developpement de l'Acétylène dans le Nord et le Midi de la France (*Rev. des Eclairages*, Sept. 30).
Zündung des Gasglühlichtes in Eisenbahnwagen (*J. f. G.*, Sept. 26).
Gegen die Gassteuer (*J. f. G.*, Oct. 17).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*
Sec. Ann. Conv. I. E. S.—Denotes a paper read at the Second Annual Convention of the Illuminating Engineering Society, which took place on Oct. 5th and 6th of this year.

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

19,365. Holders, sockets, etc., for lamps. Sept. 15. F. W. Bayliss, 18. Southampton Buildings, London.
19,395. Arc lamps. Sept. 15. H. J. J. Jaburg, jun., 111, Hatton Garden, London.
19,659. Filaments for incandescent lamps (C.S.). Sept. 18. W. P. Thompson, 6, Lord Street, Liverpool. From O. Inwald and R. von Inwald, Austria.
19,679. Safety device for portable hand lamps. Sept. 19. J. Lightfoot, 15A, Cooper Street, Manchester.
19,866. Holders, sockets, etc., for lamps. Sept. 22. F. W. Bayliss, 18, Southampton Buildings, London.
20,085. Incandescent light unit. Sept. 24. J. K. Heydon, 23, Southampton Buildings, London.
20,158. Arc lamps. Sept. 25. F. Proctor, 2, Jackson Road. Holloway, London.
20,266. Portable lamps for use in mines (C.S.). Sept. 26. The New Ignition Syndicate, Ltd., F. J. Rouse, and W. J. L. Sandy, 24, Southampton Buildings, London.
20,344. Filaments for incandescent lamps. Sept. 28. R. de Fazi, F. G. Claussen, and G. T. B. Cobbett, 37, Essex Street, Strand.
20,565. Lamps. Sept. 30. A. J. Bonnella, 9, Warwick Court, Gray's Inn, London.
20,582. Pedestal electric light fittings. Sept. 30. C. H. Fisher, 38, Chancery Lane, London.
20,715. Repairing metal filament lamps (C.S.). Oct. 1. H. Sefton-Jones, 322, High Holborn, London. (From H. Küzel, Austria).
20,877. Holders, sockets, &c., for lamps. Oct. 3. F. W. Bayliss, 18, Southampton Buildings, London.
20,915. Fastening the filaments of incandescent lamps (C.S.). Oct. 3. T. Mc. Kenna, 31, Basinghall Street, London. (From Glühlampenwerk, Auker G. m. b. H., Germany).
20,930. Lamp-holders. Oct. 5. W. Fennell and W. P. Perry, 27, St. Jude's Road, West Wolverhampton.
20,937. Arc lamps. Oct. 5. C. E. G. Gilbert, Cautley, Chingford.
21,332. Holders for incandescent lamps (C.S.). Oct. 9. C. M. Dorman, R. A. Smith and H. G. Baggs, Ordsal Electrical Works, Salford, Manchester.
21,602. Electric light stand (C.S.). Oct. 12. J. F. Pierce, Norfolk House, Norfolk Street, Strand.
21,670. Mounting incandescent lamps. Oct. 13. H. Girard, 7, Southampton Buildings, London.
21,760. Incandescent lamps. Oct. 14. C. Polden, 18, Southampton Buildings, London.
21,834. Mercury and other vapour lamps. Oct. 15. H. A. Kent, H. G. Racell and The Silica Syndicate, Ltd., 47, Lincoln's Inn Fields, London.
21,835. Suspension devices for arc lamps (C.S.). Oct. 15. J. New, 77, Chancery Lane, London.

II.—GAS LIGHTING.

19,496. Incandescent burners. Sept. 16. H. F. Boughton and F. Pudney, 276. High Holborn, London.
19,577. Burners for high-pressure lamps. Sept. 17. W. H. Chipperfield, 149, Strand, London.
19,722. Mechanism for automatic gas lighting. Sept. 19. M. G. Cowper-Smith, 1, Great James Street, Bedford Row, London.
19,723. Incandescent lamps (C.S.). Sept. 19. S. Chandler and J. Chandler, Birkbeck Bank Chambers, London.
19,731. Incandescent burners (C S.). Sept. 19. F. W. Marillier, E. H. Still and A. G. Adamson, 46, Lincoln's Inn Fields, London.
19,755. Suspension fittings for inverted burners. Sept. 21. D. Mitton, 3, Brown Street, Market Street, Manchester.
19,785. Incandescent lamps and burners. Sept. 21. J. Thomas, 53, Hanley Road, London.
20,004. Lanterns (C.S.). Sept. 23. J. Gunning, Birkbeck Bank Chambers, London. (Addition to 2960/08).
20,197. Incandescent burners (C.S.). Sept. 25. C. Dearnley, 18, Southampton Buildings, London.
20,348. Automatic lighting and extinguishing apparatus. Sept. 28. B. Bonniksen and T. Berridge, 18, Hertford Street, Coventry.
20,465. Inverted incandescent burners (C.S.). Sept. 29. C. W. Bland, 33, Cannon Street, London.
20,667. Inverted regenerative incandescent lamps. Oct. 1. R. J. Liebisch and C. Woolley, 55, Market Street, Manchester.
20,712. Incandescent burners. Oct. 1. C. W. Bland, 33, Cannon Street, London.
20,762. Lamps and burners. Oct. 2. G. Helps, Izons Croft, Ansley, Atherstone.
21,117. Economising gas in incandescent lamps. Oct. 7. J. R. Lindsay and W. Earnshaw, 55, Market Street, Manchester.

21,185. Controlling lights from a distance (C.S.). Oct. 7. J. M. Tourtel and W. R. Mealing, 33, Cannon Street, London.
21,409. Electrical ignition devices for gas lamps, etc. Oct. 10. J. Keith and G. Keith, 65, Chancery Lane, London.
21,507. Lamps (C.S.). Oct. 10. H. Köhler, 345, St. John Street, London.
21,658. Incandescent mantles. Oct. 13. A. C. Thomas, 33, Cannon Street, London.
21,669. Incandescent burners. Oct. 13. J. M. Lecomte and M. Roy. 7, Southampton Buildings, London.
21,791. Mantles and holders for incandescent lighting. Oct. 15. H. S. Thompson, 4, Corporation Street, Birmingham.

III.—MISCELLANEOUS

19,289. Oil vapour lamps. Sept. 14. F. Daintree, 3, Broad Street Buildings, Liverpool St., London.
19,344. Photometer screens (C.S.). Sept. 15. Siemens Bros. & Co., Ltd., Queen Anne's Chambers, Broadway, Westminster. (From Siemens & Halske, Akt.-Ges., Germany.)
19,545. Acetylene lamps. Sept. 17. A. Guilbert, 20, High Holborn, London.
19,719. Vapour lamps (C.S.). Sept. 19. W. Fairweather, 65, Chancery Lane, London. (From Landers, Frary and Clark, U.S.A.)
20,076. Acetylene and like burners (C.S.). Sept. 24. A. Bray, Sunbridge Chambers, Bradford, Yorks.
20,314. Lamps and lanterns. Sept. 28. J. Neville, 78, Trintonville Road, Sandymount, Dublin.
20,341. Lamp burners or sockets. Sept. 28. A. Godefroy and H. Lemaire, 20, High Holborn, London.
20,610. Incandescence vapour lamps. Sept. 30. Kitson Empire Lighting Co., Ltd., and R. H. Stephens, Birkbeck Bank Chambers, London.
20,713. Burners for incandescent lighting by oil or spirit. Oct. 1. W. G. Potter, 14, Ingleton Street, Brixton, Surrey.
20,794. Hurricane and like lanterns. Oct. 2. D. Cunningham, 33, Cannon Street, London.
20,806. Production of light. Oct. 2. C. K. P. Eden, Westinghouse Buildings, Norfolk Street, Strand.
20,883. Incandescent lighting (C.S.). Oct. 3. A. J. Boult, 111, Hatton Garden, London. (From L. Hooker, New South Wales.)
21,725. Illuminated signs. Oct. 14. W. J. Beville, 1, Stock Orchard Crescent, Holloway, London.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

24,027. Arc lamps (C.S.). I.C. Sept. 7, 1907, Germany. Accepted Oct. 7, 1908. D. Timar and K. von Dreger, 7, Southampton Buildings, London.
25,355. Arc lamps. Nov. 15, 1907. Accepted Sept. 30, 1903. P. M. Capitaine, 43, Boulevarde Voltaire, Paris.
25,831. Cluster sockets (C.S.). I.C. Nov. 22, 1906, U.S.A. Accepted Oct. 14, 1908. G. A. Harter, 165, Queen Victoria Street, London.
461. Incandescent lamps. Jan. 8, 1908. Accepted Oct. 7, 1908. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
3,464. Arc lamp (C.S.). I.C. Feb. 18, 1907, Sweden. Accepted Oct. 14, 1908. L. S. Andersson, 65, Chancery Lane, London.
4,760. Conducting connection for use in incandescent lamps (C.S.). Mar. 2, 1908. Accepted Oct. 14, 1908. H. W. Lake, 7, Southampton Buildings, London. (From Elektrische Glühlampenfabrik Watt, Scharf, Loti & Latzko, Austria.)
5,318. Sockets for incandescent lamps (C.S.). I.C. Mar. 15, 1907, U.S.A. Accepted Oct. 14, 1908. F. A. Swan, 72, Cannon Street, London.
5,560. Incandescent lamps. Mar. 12, 1908. Accepted Oct. 14, 1908. C. H. Stearn and C. F. Topham, 47, Lincoln's Inn Fields, London.
6,245. Metal filament lamps (C.S.). I.C. Mar. 27, 1907, Germany. Accepted Oct. 14, 1908. The Westinghouse Metal Filament Lamp Co., Ltd., Westinghouse Buildings, Norfolk Street, Strand.
10,891. Filaments for incandescent lamps (C.S.). I.C. Oct. 7, 1907, Germany. Wolfram-Lampen. Akt.-Ges., 7, Southampton Buildings, London.
18,054. Incandescent lamps (C.S.). I.C. Sept. 16, 1907, U.S.A. W. C. Arsem, 83, Cannon Street, London.
19,311. Tungsten incandescent bodies (C.S.). I.C. Sept. 26, 1907, Germany. Siemens & Halske, Akt.-Ges., Birkbeck Bank Chambers, London.
19,847. Preventing disintegration of incandescent filaments (C.S.). I.C. Oct. 3, 1907, Germany. Glühlampenwerk Auker G. m. b. H., 31, Basinghall Street, London.
19,932. Incandescent filaments of tungsten or its alloys (C.S.). I.C. Sept. 26, 1907, Germany. Siemens & Halske, Akt.-Ges.. Birkbeck Bank Chambers, London.
21,385. Vacuous metallic filament lamps (C.S.). I.C. Nov. 2, 1907, Germany. Siemens & Halske, Akt.-Ges., Birkbeck Bank Chambers, London.

II.—GAS LIGHTING.

21,691. Incandescent fittings. Oct. 1, 1907. Accepted Oct. 7, 1908. J. W. Blakey, 8, Alexandra Street, Bradford.
26,501. Gas heating and illuminating apparatus. Nov. 30, 1907. Accepted Sept. 23, 1908. S. N. Wellington and W. P. Gibbons, 33, Chancery Lane, London.
28,393. Inverted incandescent lamps. Dec. 24, 1907. Accepted Sept. 30, 1908. S. Biheller, 1, Great James Street, Bedford Row, London.
227. Appliances for use with incandescent lamps. Jan. 4, 1908. Accepted Sept. 30, 1908. S. A. Jackson, 317, Regent Road, Salford, Lancs.

1,026. Supporting incandescent mantles. Jan. 16, 1908. Accepted Sept. 23, 1908. M. Kriegel, Prudential Buildings, Corporation Street, Birmingham.
8,730. Automatic ignition and control (C.S.). April 21, 1908. Accepted Sept. 30, 1908. P. Jensen, 77, Chancery Lane, London. (From. L. G. Bartlett, U.S.A.)
10,782. Inverted incandescent lamps (C.S.). I.C. May 17, 1907, Germany. Accepted Sept. 30, 1908. T. Eberhard, 56, Myddleton Square, London.
11,122. Incandescent burners (C.S.). May 22, 1908. Accepted Sept. 23, 1908. H. W. Lake, 7, Southampton Buildings, London. (From Neue Kramerlicht-Ges., m. b. H. Germany.)
11,942. Inverted incandescent burners (C.S.). June 2, 1908. Accepted Oct. 14, 1908. A. L. Dunphy and J. Tysoe, 163, Queen Victoria Street, London. (Addition to 20/07.)
19,315. Automatic ignition of gas lights (C.S.) I.C. Sept. 14, 1907, Switzerland. H. Ruppert, 6, Lord Street, Liverpool.

III.—MISCELLANEOUS

22,036. Filaments for illuminating and heating (C.S.). Oct. 5, 1907. Accepted Oct. 14, 1908. W. E, Lake, 7, Southampton Buildings, London. (From G. Michaud and E. Delasson, France.)
26,504. Holders for lamps, globes, mantle supports, &c. (C.S.) I.C. Dec. 1, 1906, Germany. Accepted Sept. 30, 1908. O. Mannesmann, trading as Sparlicht-Ges. m. b. H., 53, Grabenstrasse, Essen-on-the-Ruhr, Germany.
27,350. Gas and electric lighting for spinning frames, &c. Dec. 11, 1907. Accepted Sept. 30, 1908. H. M. Girdwood, 17, St. Ann's Square, Manchester.
28,004. Search lights. Dec. 19, 1907. Accepted Sept. 23, 1908. Siemens Bros. Dynamo Works, Ltd., and G. S. Grimston, 139, Queen Victoria Street, London.
136. Electric lamp and shade holders for oil lamp reservoirs. Jan. 2, 1908. Accepted Sept. 23, 1908. A. H. Entwistle, 8, Quality Court, Chancery Lane, London.
16,440. Flash-light apparatus (C.S.). May 14, 1908. Accepted Sept. 23, 1908. J. P. O'Hea, 133, Ruthey Green, Catford, London.
20,746. Condensing globe or lamp shade (C.S.). I.C. Oct. 3, 1907, Belgium. B. Bronislawski, 24, Temple Row, Birmingham.
21,667. Suspending device for incandescent bodies (C.S.). I.C. Oct. 16, 1907, Germany. A. Martini, 31, Bedford Street, Strand.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application; date applied for under Rule 13.

Accepted.—Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

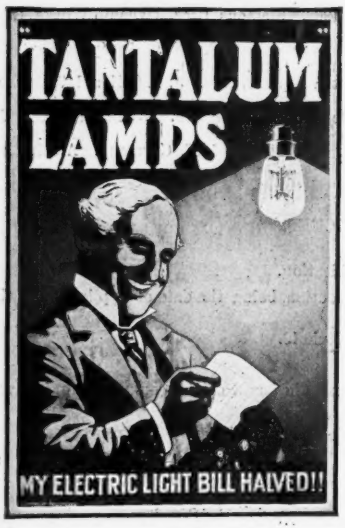
Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

We note that Mr. L. B. Marks, consulting illuminating engineer, and formerly President of the Illuminating Engineering Society, and Mr. J. E. Woodwell, recently engineer in the United States Government service, Washington, have opened offices in the Terminal Building, 41st Street, New York City.

Trade Notes, Catalogues Received, &c.

During the last month we have received from *Messrs. Siemens Bros.* several notes relating to the development of Tantalum lamps. We are informed that this firm have placed a large contract for bill posting on public hoardings in the provinces and on the "Underground" in London. The picture in question, representing an evidently satisfied consumer, is shown in the adjoining illustration. We are asked to state a reproduction of the same in show card form can be supplied from the Company's Offices in Bath Street, City Road, E.C.



We have since been informed that the demand for the new Tantalum show-cards exceeded expectations, and some delay in delivering occurred; reprints, however, were in course of preparation, and are doubtless now available. We have also to acknowledge the receipt of a neat little booklet from the same firm, measuring 3½ in. to 6 in., and giving particulars of various types of Tantalum fixtures and installations.

The Holophane Co. send us the September number of their bulletin, which is, as usual, tastefully got up, and contains full description and particulars of the d'Olier metal reflectors. This number includes a reprint of a recent article by Messrs. Cravath and Lansingh entitled "Some Preliminary Calculations of Illumination."

The Union Electrical Co. send us current lists describing the "Union" auto-transformers for use with metallic filament lamps, which are listed for the reduction of standard pressures ranging from 100 to 250 volts; also lists giving particulars of the "Fortiter" Resistance apparatus, and Excello Carbons, and alternating current arc lamps. This firm also send us an account of the exhibit of arc lamps at the Manchester Electrical Exhibition. Excello white and yellow flame arcs were largely employed, and there were also exhibitions of the inverted system of lighting.

The *Quarzlampen-Gesellschaft*, of Paukow, Berlin, send us a series of pamphlets describing the new Küch quartz tube mercury vapour arc lamp. It is claimed for these lamps that they yield 3,000 H.K., taking a current of 3½ ampéres, and burning direct on 220 volts, and that they will burn 2,000 hours without any attention.

Messrs. Porter and Co., of Lincoln, send us an attractive pamphlet describing some of the gasholders installed by this firm, and also undertake the supply of ironwork, tanks, &c., of all descriptions, as employed in gas manufacture.

The Heatley-Gresham Engineering Co. send us an illustrated descriptive pamphlet of their patent oil engines, "Rational" electric lighting sets, deep-well pumps, and switch-boards, &c.

We have also received a little booklet setting forth the claims of the *Mitchellite* petrol air gas system, which is stated to be "cheaper than coal gas, non-explosive, and absolutely automatic."

Messrs. Heller & Knappich, of Augsburg send us a description of their "Baldur" Acetylene Gas-Generators, together with a booklet describing the oxy-acetylene system of welding.

ERRATA.—October Number, p. 854. In title, for "Hint" read "Unit."
" " p. 847. In heading below Fig. 3, for "ft." read "inch."



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The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

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EDITORIAL.

A Year's Progress.

THE present number completes the first volume of *The Illuminating Engineer*, and the moment is perhaps opportune to express our appreciation of the great interest and sympathy with which our objects have invariably been received at the hands of authorities in different countries—a degree of appreciation that bears witness to the general recognition of the value of the work we are trying to carry out.

Although, at the beginning of our movement, there were a few instances in which our intentions were not fully realized or were misconstrued, the publication of our views during the time that has elapsed since then has done much to show that it was only on misapprehension that these objections were grounded, and we feel confident that our desire to see the subject of illumination brought before the combined notice, and made the subject of concerted action of the architectural, medical, and engineering professions is now generally approved. We are glad to be able to record indications that the desired *rapprochement* between these authorities is gradually coming about.

The attention drawn to the subject of illumination in the technical press, on which we commented some time ago, is still increasing. On this occasion we should like to acknowledge the courtesy of the many distinguished societies and technical journals who have accepted an exchange of publications; many of them now habitually deal with matters of illumination, though they would have considered it out of their province to do so a few years ago.

And in addition, we feel that special acknowledgment is due to the kindness and courtesy of the Council of the Illuminating Engineering Society of New York, in putting at our disposal the official records of their proceedings, thus enabling us to provide first-hand information on the subject of the progress of illuminating engineering in the United States.

The doings of the Illuminating Engineering Society in America deserve special attention at our hands in this country, for the conditions

in both countries resemble each other sufficiently closely for us to draw useful conclusions from their experience.

In the present number we again devote special attention to the papers read at the Convention and the interesting discussion to which they gave rise.

One illustration of the readjustment of views mentioned above is presented by the gradual change of attitude towards one another that is slowly but surely coming about among those representing different systems of lighting.

It is true that the perpetual wrangle as to the relative cheapness of gas and electricity still proceeds in some quarters, each of the disputants professing to be staggered by the iniquity and misrepresentations of the other; but the ferocity with which these discussions were often formerly conducted, we are glad to note, has lessened of late years. To the impartial onlooker it seems self-evident that many supposed misrepresentations are really based on mutual misunderstanding, or on want of appreciation of general conditions, and over-accentuation of some detail. And any one who has been called upon to advise as to the selection of different methods of lighting, must realize that each case must be considered on its merits, and that he has to bear in mind very carefully the exact conditions under which the illuminant is to be used.

His decision must be based not merely upon the running cost of the two illuminants under consideration—gas and electricity, for example. He must also bear in mind the costs of maintenance and renewals, taking into account the local conditions. And at the same time he must not lose sight of the æsthetic and hygienic aspects of the question; good illumination, as we pointed out above, can only be obtained by the concerted action of the physiologist, the architect, and the engineer.

In reality there is room for the existence of alternative systems of illumination, and it is our desire to indicate the conditions for which each of these systems is best adapted in an impartial manner. In this connexion it must not be forgotten that the consumer is now showing a much more critical attitude than formerly, and his increased interest in matters of illumination is to be regarded as a hopeful sign for the future.

It is particularly gratifying to observe that some of our contemporaries rightly condemn not merely the circulation of statements which they regard as untrustworthy on the part of competitors, but also deprecate the issue of misleading general claims by those engaged in the branch of lighting with which they are mainly concerned.

We appreciate the spirit that prompts the contentions that: "It is bad policy to attack a rival system of illumination"; that such tactics meet with their own reward; and that retaliation is not only undesirable but inexpedient.

Library-Lighting.

In the present and the last number of *The Illuminating Engineer*, we have devoted a considerable amount of space to the exhaustive description of the method of illuminating the Carnegie Libraries in New York, as presented by Mr. L. B. Marks at the Convention of the Illuminating Engineering Society. In doing so we have been actuated mainly by consideration of the exceptional and complete nature of the results which Mr. Marks's paper contains, and which, we think, should serve as a very valuable record to those studying the lighting of libraries in the future.

With the possible exception of school-room lighting, it is difficult to think of any conditions under which good illumination is more essential. A library, exists for reading, and the mere act of continuous reading, even under favour-

able conditions is one that entails a quite exceptional amount of effort on the eyes; in the case of libraries devoted to science, technical matters, and serious reading generally, there is also a degree of mental effort to be considered, which is accentuated by imperfect day or artificial lighting.

In addition it must be recalled that many libraries are not only erected at great expense themselves, but contain accumulated reading matter which it is often literally impossible to replace, and which is collected only by the long and laborious effort of many years.

A library therefore represents emphatically one of those cases in which the combined assistance of the architect and engineer is essential. In most libraries, the conditions of daylight illumination are exceptionally important, and whether they are favourable or the reverse depends on the structure of the building. They are also very frequently buildings on which considerable care has been lavished in order to secure agreeable results from the architectural point of view, and in which, therefore, it is natural to make special efforts to secure that the system of illumination is in harmony with the general scheme. We are pleased to observe that the conditions of illumination in the New York libraries described by Mr. Marks are the result of co-operation of this description. It will be interesting to observe how far the methods adopted in this case are ultimately accepted as a recognized basis for the scientific illumination of libraries. But this is only one among many recent instances in which the value of the services of an illuminating engineer has been recognized in connexion with the lighting of an important building.

Another instance in which the appreciation of good illumination on the part of the architects concerned seems to have led to very successful results, is presented by the new public library in Fifth Avenue, New York, described by Mr. J. F. Musselman in a recent number of *The Electrical World*. Special attention was given to the illumination of the shelves of books in order to secure that their titles could be clearly read.

Another feature of the arrangements is that fire-proof material is employed everywhere throughout the stack-rooms, these being provided with adequate artificial illumination. This, again, is a feature that ought to be borne in mind in the building of special homes for libraries.

Moreover, it should be borne in mind that a very large proportion of earnest readers are unable to visit libraries during the daytime, and in their case some good system of artificial illumination, at once absolutely safe and physiologically correct is extremely essential.

Now that so many libraries are being erected, and new illuminants are available, this aspect of the matter deserves special attention.

A Tax on Light.

The action of the German Government in proposing a tax on gas and electricity, for power and lighting, has naturally given rise to a considerable amount of discussion among the technical journals in that country. For our part we are reluctant to criticize the legislation of a foreign country when devoted to subjects that are, strictly speaking, their own concern; but we must confess that, on the present occasion the creation of a tax on the lines proposed seems to establish such an undesirable precedent that comment is justifiable.

The details of this proposed tax have now been published. Gas is to be taxed at the rate of ½ pfennig per cubic metre (about 1½*d.* per 1,000 cubic feet), and there is to be a corresponding tax of 0·4 pfennigs per unit on electricity. In addition, we understand that a specfiic rate on illuminating apparatus is to be levied, amounting to 10 pfennigs (about 1*d.*) in the case of incandescent gas-mantles, and

varying from 5 to 50 pfennigs in the case of electric lamps of various kinds, according to their candle-power.

As we have repeatedly and emphatically pointed out, adequate illumination is not a luxury but an absolute necessity — as vital as good sanitation or fresh air. The great difficulty against which reformers have had to contend until recently has been the lack of recognition of this fact, and people are still inclined perpetually to "scrimp" the illumination down to a margin which it would frequently be preferable greatly to exceed, simply from motives of economy. Anything, therefore, that tends to induce people to reduce their necessary amount of light is extremely to be regretted. Possibly the agitation that is now in progress against the imposition of this tax may not be without beneficial results in this connexion.

Cheaper Electric Lamps.

Some excitement has been caused in the electric lighting industry by the announcement of a considerable reduction in prices, under the circumstances, of certain metallic filament lamps. It is freely predicted that this is only the prelude to a more wholesale reduction.

From the consumer's standpoint, a *bona fide* reduction in price without a corresponding reduction in *quality* is obviously a great gain. The high prices of metallic filament lamps have hitherto militated against their wholesale acceptance, and a fall in cost will have the beneficial effect of inducing the consumer to adopt a better standard of illumination.

But at the same time it must be recognized that any change of this description carries with it certain dangers, from which we suffered in the days when only carbon filament lamps were available, and which we would do well to take precautions to avoid now that similar conditions seem likely to recur. The usefulness of the present standard specification, as prepared by the Engineering Standards Committee, admirable in scope as it undoubtedly is as regards carbon filament lamps, must be impaired by the fact that, in the nature of things, it will soon be rendered obsolete by the greater development of the metallic filament. The time is now coming when some such protection against the possible introduction of inferior articles is needed in the case of lamps of this description.

It has often been stated that in the past, vast numbers of defective carbon lamps, which could not be disposed of at home, not infrequently because they did not comply with the required specification, were shipped over to this country and sold at a ridiculously low price.

This greatly harassed the sale of genuine lamps, at a reasonable price, in this country, and indirectly prejudiced the development of electric lighting. The bad results obtained from the use of inferior lamps naturally tended to bring the system into disrepute. In the absence of any legal prescription as to the performances of metallic filament lamps, regarding the marking of lamps with a specified pressure, candle-power, life, and consumption, we may well fear a repetition of these evils, and it is to be hoped that authoritative action in this respect may soon be taken, without unduly interfering with the natural development of the lamp industry. Meanwhile we observe that the subject is under consideration in Germany, a set of experimental and tentative regulations for the purchase of their own lamps having been provisionally adopted.

With this matter we hope to deal in greater detail on a future occasion.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 975) continues his series of contributions, the present section again dealing with the subject of PHOTOMETERS. On this occasion the HARCOURT and BUNSEN types of instruments are described. Some directions as to the construction of sensitive grease-spot screens are given, and the principles on which the action of such screens is based explained.

Mr. Chas. W. Hastings (p. 979) deals with the EDUCATION OF THOSE CONCERNED WITH THE PRODUCTION AND UTILIZATION OF LIGHT, paying special attention to the system of examination undertaken by the City and Guilds of London Institute.

Prof. J. T. Morris and **Mr. J. G. Farrow** (p. 985) contribute the results of some researches on the ABSORPTION OF ARC-LAMP GLOBES. A number of different globes were examined, polar curves of distribution of light being plotted in each case, and the results are summarized in a comprehensive table. From these experiments the authors draw one important conclusion, namely, that it is only possible to form a correct estimate of the absorption by determining the mean spherical candle-power; for this purpose a globe-photometer seems desirable, as the work is otherwise very laborious.

Mr. J. Rosemeyer (p. 991) contributes a discussion of MODERN DEVELOPMENTS IN THE ARC-LAMP, dealing, in this section, particularly with progress in the enclosed arc-lamp, and the advantages that have been secured by completely enclosing the arc so as to prevent the air making a partial entry, and thus causing the rapid oxidation and formation of ash on the part of the carbons.

Mr. W. B. v. Czudnochowski (p. 997) contributes a preliminary account of the recent EXHIBITION OF NAVAL ARCHITECTURE AND SHIPBUILDING IN BERLIN, from the standpoint of illumination.

The **Special Section,** in the present number, is again devoted to the papers read at the SECOND ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY. On this occasion the PRESIDENTIAL ADDRESS of **Dr. Louis Bell** is reproduced (p. 999). This deals mainly with STREET-LIGHTING, Dr. Bell emphasizing the fact that modern conditions demand an entirely different order of illumination from what was considered sufficient a few years ago, and giving some of the impressions derived during his recent tour in Europe, with the object of studying Continental developments. One feature of lighting in the United States to which he draws attention is the tendency to illuminate an entire town with equal brightness, instead of specializing in the illumination of the most important thoroughfares.

The comprehensive paper on the ILLUMINATION OF THE CARNEGIE LIBRARIES IN NEW YORK, by **Mr. L. B. Marks,** and the subsequent discussion, is completed in the present number (p. 1009), full particulars being given of the order of illumination provided on the tables and on the bookshelves, and the fixtures and methods of placing them adopted in order to secure these results.

A paper by **Mr. H. E. Ives,** describing the use of his COLORIMETER IN ILLUMINATING ENGINEERING (p. 1019), also appears in this section. In this paper Mr. Ives gives particulars of researches with his instrument on various types of illuminants and various coloured surfaces, and presents a table comparing the colour-values of these different sources. A spirited discussion followed this paper, in which **Mr. MacFarlane Moore, Mr. E. L. Elliott, Mr. E. P. Hyde,** and others took part.

A paper by **Mr. E. D. Wrightington** describes his impressions of European STREET-LIGHTING BY GAS (p. 1024). One feature of American street-lighting which differs from Continental ex-

periences in many towns is referred to by the author. A much larger amount of light, he states, is derived from show-windows, illuminated signs, and other private lighting in that country.

Mr. T. J. Litle (p. 1025) discusses MODERN GAS-LIGHTING CONVENIENCES, dealing particularly with the existing methods of automatic extinction and kindling of gas-lamps, by the pneumatic, electrical, and other methods. The discussion of this paper, here reproduced in abstract, turned largely on the question of insulation for electric igniting systems.

A paper by **Dr. Clayton Sharp** and **Mr. Preston Millar** (p. 1031) describes some experiments with the integrating globe-photometer, including an investigation of the errors arising from the presence of foreign bodies within the sphere, and their effect on the performances of globes of various sizes.

The paper by **Messrs. Y. R. Lansingh** and **J. R. Cravath** discusses the APPLICATION OF THE CONCEPTION OF THE FLUX OF LIGHT TO PRACTICAL PROBLEMS OF ILLUMINATION (p. 1036). This is followed by a table containing some actual results in watts per square foot obtained in the case of a number of different illuminants and rooms equipped with wall-paper and ceilings of different character.

An abstract is also given in this section (p. 1005) of the discussion of the papers by Dr. A. C. Humphreys, Mr. L. B. Marks, Dr. A. H. Elliott, Mr. J. E. Woodwell, Mr. E. G. Perrot, and Mr. L. J. Lewinson, in our last number.

Among the other articles occurring in this number attention may be directed to the description of a method of ILLUMINATING SHOP-WINDOWS BY HOLOPHANE REFLECTORS on p. 982. Particulars are also given of some demonstrations of the effect of using suitable reflectors, to concentrate light in any desired direction, and diffusing globes in order to distribute the light in a more scientific manner.

Another article refers to the suggested scheme of utilizing ELEVATED STREETS IN NEW YORK and its probable effect on conditions of street-lighting (p. 996).

On p. 1043 will be found an abstract of a recent paper by **Prof. Blondel,** dealing with RECENT PROGRESS IN INCANDESCENT LAMPS, and reviewing the scientific principles on which the recent modifications are based.

An article by **Mr. F. Musselman** (p. 1042) describes the scheme of illumination employed for the ILLUMINATION OF THE STACK-ROOMS IN A NEW YORK LIBRARY, and an article on p. 1041 gives some particulars of a suggested basis of a STANDARD SPECIFICATION FOR METALLIC FILAMENT LAMPS, as suggested in Munich.

The **Correspondence** columns in the present number (p. 1049) contain letters on a wide range of subjects. **Dr. Stockhausen** writes to reply to Dr. Voege's recent remarks on the subject of the effect of ULTRA-VIOLET LIGHT IN ARTIFICIAL ILLUMINANTS ON THE EYE.

Mr. A. J. Marshall wishes to modify the views attributed to him in a previous number on the subject of the advisability of using LIGHT SYMBOLS ON DARK BACKGROUNDS for physiological reasons.

Dr. E. W. Marchant discusses in greater detail the method proposed by him of measuring the absorption of arc-light globes, replying to the criticisms of Mr. A. Denman Jones on this point.

A description is also given of a modification of the HARRISON UNIVERSAL PHOTOMETER, which enables this instrument to measure ILLUMINATION IN A HORIZONTAL PLANE.

At the end of the number will be found the usual **Review of the Technical Press** and the **Patent List.**

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

(*Continued from p.* 889.)

The Harcourt Photometer.—The photometer in use at the present day in the official tests of the Metropolitan Gas Referees, is essentially that of Bouguer, and the historical order may be interrupted to describe it. These officials and other gas engineers use the word photometer to include a diverse collection of gas-testing apparatus, and the particular instrument which would generally be described as a photometer is called by them a photoped (Fig. 50).

It consists of two plates, each having a hole 21 millimetres ($\frac{7}{8}$ in.) square. Between these a piece of suitable paper is pinched. A short tube slides within this, and carries a diaphragm having a rectangular opening 25 millimetres (1 in.) high, and 7 millimetres ($\frac{9}{32}$ in.) wide. Two rectangular spaces on the white paper are illuminated by the two lights, and by sliding the tube these spaces can be arranged so as to meet without perceptible overlapping, provided that the dimensions of the lights are small compared with their distance from the diaphragm.

It is important that the angle of incidence of the light shall be the same for each half of the screen. "This," wrote Rumford in the first of the two letters to Sir Joseph Banks, "may be easily performed by actually placing a piece of looking-glass, 6 or 8 in. square, flat upon the paper, in the middle of it, and observing by means of it the real lines of reflection of the lights from that plane, removing it afterwards as soon as the lights are properly arranged."*

In the Harcourt photometer a mirror is mounted above the screen, and is tilted slightly forwards. This is shown in the illustration.

If the photoped is symmetrically placed with respect to the two lights, the reflection of one in the mirror appears centrally over the other. If this is not the case the photoped is turned on its stand until the adjustment is exact. A dark screen 350 mm. ($13\frac{3}{4}$ in.) square, with a square hole in it, is placed between the observer and the photoped, and various other screens are suitably placed to cut off stray light. The official description of the material to be used for the screen is as follows: "The paper used in the photoped of the photometer shall be white in colour, unglazed, of fine grain, and free from water marks. It shall be as translucent as is possible consistently with its being sufficiently opaque to prevent any change in the apparent relative brightness of the two portions of the illuminated surface, when the head is moved to either side."

One of the lights is generally fixed at 1 m. from the paper screen, and the other is moved on a slide by means of a rod. This rod carries a graduated scale which is read against a fixed pointer. The movable light is adjusted

* Thompson, *Phil. Trans. Roy. Soc.*, 1794. p. 68.

until the illumination of the two halves of the screen appear to be the same.

The angular adjustment with reference to the lights has a twofold effect on the balance of illumination of the screen. It is evident that if the screen faces directly towards one light, it is receiving the maximum illumination that is possible at that distance, and that the illumination due to the other light will be less. It is possible to use the rotation of the photoped as a fine adjustment. After making an adjustment for the balance of two lights in the ordinary way, with the photoped symmetrical, one light is moved to give, say, 2 per cent difference of

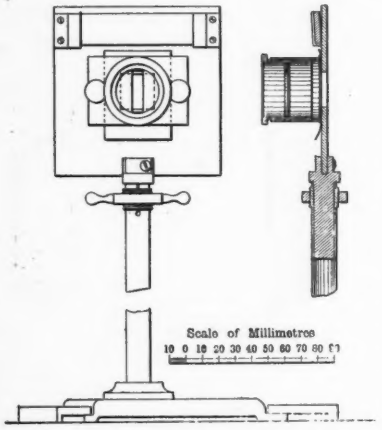


FIG. 50.—The Vernon-Harcourt, Gas Referee's Photometer.

illumination, the photoped is rotated on the vertical axis until a balance is obtained, and the angle of rotation is noted. The light is again moved, and another angular adjustment made. The relation between the angles and the known differences may be found graphically, and an angular scale may be graduated for photometric measurements.

The Bunsen Photometer.—Having departed from the historical order, the description of the Ritchie photometer, which is the prototype of many varieties, may be postponed, and the well-known Bunsen photometer, of which there are only two forms, may be taken. It is a singular fact that while elementary textbooks of physics generally include a brief description of the Bunsen photometer, that description, except in a very few cases, is not only wrong and misleading, but is discordant with a simple experiment which any one can make, and the same mistake is to be found in books on photometry. The Bunsen photometer is usually described as consisting essentially of a spot of grease on white paper, or more scientifically, "a paper screen made unequally translucent in different parts, either by means of a circular, or better still, ring-shaped spot of grease or stearin, or even by covering a part of a thin paper with a second thickness."*

This screen is placed between the two lights, and according to one well-known book, "the method consists in sliding the photometer disc along the scale until the spot appears of the same brightness as the rest of the paper; the intensities of the lights are then proportional to the squares of their distances from the disc." Another excellent textbook says: "The lights to be compared are placed on opposite sides of this screen, and their distances are so adjusted that the grease-spot appears neither brighter nor darker than the rest of the paper, from whichever side it is viewed." It is difficult to believe that the writers of these descriptions can ever have tried the simple experiment. If a sheet of paper with a spot of grease on it is placed between two lights, it is generally possible to find a position at which the spot, when viewed from one side and at a certain angle, becomes almost invisible. But a change of the point of view will alter the balance, and the appearance on the other side is always quite different. The law of diffusion of light through translucent substances makes it impossible that there should be a complete disappearance. Some writers having, perhaps, made some such experiment, and feeling rather uneasy about the result, attribute the departure from their preconceived notion, to a defect in the preparation of the grease spot or to want of uni-

* Kohlrausch, 'Physical Measurements.'

formity in the two surfaces of paper of which the disc is made. This widespread mistake is due to a desire to make the description simple. The erroneous description is often illustrated by a representation of two lights and a disc between them, provided with a grease-spot of this imaginary kind.

Mr. W. L. Dibdin, describing Bunsens original photometer,* which was inv'ented in about 1841, says that the disc of paper marked with grease was enclosed in a box in which was burning a small gas-flame. The flame illuminated one side of the disc, the reverse side of which was turned to one of the lights under comparison, and the distance noted. The box was then turned round, so that the disc faced the second light; a second reading was taken, and the distance thus found used for ordinary calculation. It appears that a system of double weighing was used, and it is probable that in this method a disappearance of the spot was aimed at.

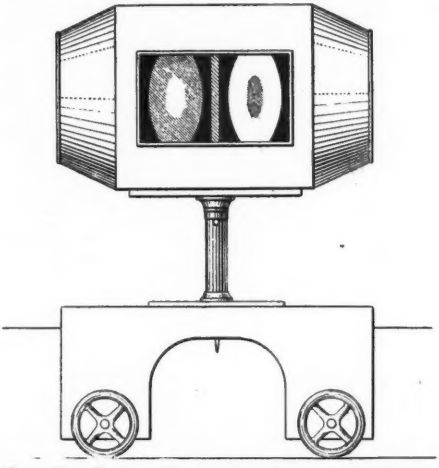


FIG. 51.—Bunsen Photometer, front view, showing the spot out of balance, owing to the illumination of the disc being greater on the right than on the left.

The modern Bunsen photometer consists of a grease-spot on a piece of paper, but it is always provided with two mirrors equally inclined, which enable both sides of the spot to be observed without any change of position of the observer, and the views of the two sides are seen at the same angle (Fig. 51). The angle is immaterial, an angle of 130 degrees or 140 degrees between the mirrors is convenient (see Plan, Fig. 52). The two images are necessarily separated, and some care is needed to avoid shadow of the mirrors on the disc. More or less complicated arrangements of prisms have been proposed to bring the images together, but these cannot be used without eye-pieces.

When the balance is effected the spot does not disappear, but the appearance of the two sides is identical

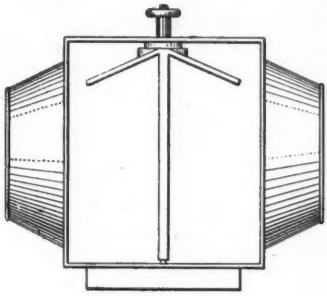


FIG. 52.

Bunsen Photometer, plan, showing disc-holder and inclined mirrors.

In order to avoid stray light the screen, or the disc, as it is called by gas engineers, and the mirrors are always protected by a box. The box is mounted on a carriage which slides on a bar. In photometers having pretensions to high accuracy a double bar or two rods are arranged as an optical "bench." For most purposes the simple bar is better. The carriage may run on wheels, or may be mounted on a mere saddle lined with cloth to reduce friction and to give a smooth, easy motion. The carriage is provided with an index—it sometimes carries a prism or small mirror which reflects

* W. J. Dibdin, 'Practical Photometry,' p. 3.

the light of one of the lamps on to the scale. A shutter is sometimes used, concealing the index until a reading is to be taken. This is in order to prevent bias. The most conscientious observer is apt to have his judgment disturbed if he can easily see the index and scale while he is adjusting a balance. The box and carriage of this and most other kinds of photometer is called the photometer head.

To make a sensitive Bunsen spot requires some skill and experiment. Good white blotting paper is an excellent material, but it is liable to become dirty. Thin drawing-paper is almost as good, but the size with which it is hardened resists the wax. There should be no perceptible watermark. A variation from the simple round grease-spot is desirable, and it is a mistake to have a large one.

A good star-shaped or ring-shaped spot may be made as follows: Cut a star out of sheet metal, not less than $\frac{1}{16}$ in. (or 2 mm.) thick, about 1 inch (or 25 mm.) over the points; or a washer 1 in. in diameter with a hole $\frac{3}{8}$ in. (or 10 mm.) diameter. Fasten it to a handle, melt a little paraffin wax or ordinary candle-grease in a cup, warm the star or washer, dip it into the wax, and then let it drain. The amount of wax that drains off depends on the temperature. Lay the paper disc on a sheet of blotting paper, and press the waxed tool on it. If the temperature is suited to the kind of paper employed, a neat uniform spot, practically alike on each side, may be made. The disc is mounted in a holder capable of rotation on a vertical axis. This enables any slight difference between the two slides to be detected. If any material difference is found on reversal the disc should be rejected.

The only modification of the Bunsen disc that need be described is the Leeson disc. This consists of three sheets of paper; the two outer sheets are rather transparent, but not nearly so transparent as tracing paper, and the third sheet which is placed between them is of a stouter quality, and has a star-shaped hole. The difficulty of constructing such a disc is in holding the sheets closely together without cockling. It is not more sensitive than a good grease-spot.

Much theorizing has been done about the action of the Bunsen disc. One of Lambert's simple axioms and a list of imaginary coefficients have been used as the basis for a string of algebraical expressions. But it is difficult to see how this mathematical treatment can help any one to make a better grease-spot, or to use it to greater advantage when it has been made. Some calculations seem to aim at securing tolerably good results from very bad discs.

(*To be continued.*)

PROF. W. E. AYRTON, F.R.S.

It is with deep regret that we record the death of Prof. Ayrton, who passed away on Sunday, November 8th, at the age of sixty-one years.

Prof. Ayrton's many distinctions and achievements need not be detailed here; nor is it possible to do more than refer to his versatile and original pioneering work in the fields both of pure science and engineering, by which he won such wide-spread and deserved recognition. But it is of interest to recall his early work in illumination and photometry, carried out at a time when these subjects were less generally appreciated than at present.

Prof. Ayrton's unique educational work will also not soon be forgotten. As a teacher he possessed in a marked degree the power of inspiring students with his own enthusiasm and energy, and inducing them to share his own lofty ideals.

His loss will be very widely regretted, and we desire respectfully to join in the general expression of sympathy with his sorrowing relatives, and in particular with Mrs. Ayrton, whose distinguished researches on the electric arc and other matters are doubtless well known to our readers.

Artificial Illumination and the Education of Those Concerned in its Production.

By Charles W. Hastings.

(*Concluded from p.* 486.)

In the June number of *The Illuminating Engineer* the writer summarized some of the educational requirements of the illuminating engineer; he will proceed to more definitely handle the subject in this article.

Practically the only educational course available is that set down by the examiners appointed by the City and Guilds of London Institute. The sections devoted to gas engineering and gas supply have been greatly improved; this improvement commenced with the appointment, as examiner, of Mr. Alfred F. Browne, one of the engineers of the South Metropolitan Gas Company, and was followed up by Mr. J. H. Brearley of the Longwood, Huddersfield Gas Works, and by the appointment, quite recently, of Mr. W. Doig Gibb, the immediate Past-President of the Institution of Gas Engineers and engineer of the Newcastle and Gateshead Gas Company. It would be far too heavy an undertaking to review the past questions set for students, but in the programme for the session 1908–9 is to be found ample proof that the study of illumination takes its proper place. To-day with gas engineers all that appertains to the advancement of gas consumption is matter of most vital import; the engineering of gas works and the manufacture of gas has reached almost perfection. The appreciation of machinery in the works has received the closest attention and the carbonization of coal has so greatly improved that to-day it is possible to obtain from the coal the utmost quantity of luminous gas; this having been accomplished, all those associated with gas undertakings are turning their best attention to the question of supply, distribution, and the methods of using gas as an illuminant; the advances made are simply astounding, and the younger men are naturally being trained to appreciate for themselves, by means of research and experiment, the still latent powers of gas illumination. This is being brought forward by the examinations already mentioned. In the Ordinary Grade under questions on gas engineering we find the following, which bear directly upon the education of the illuminating engineer:—

> The fitting up of premises for the supply of gas for light, heat, and power; the construction, testing, and fixing of gas meters. The influence of temperature and pressure on the volume of gas.
>
> The construction of various types of gas-burners; the simpler physical and chemical principles involved in the combustion of gas. The economy and efficiency of incandescent lighting as contrasted with luminous flames. High pressure lighting.

In the Honours Grade the subject of illuminating gas is handled a little more deeply, although, of course, some of the same ground is covered; from the syllabus we select the following questions:—

> Chemical composition and physical properties of coal gas and the influence of each component upon the illuminating power and calorific power of the gas.
>
> Theory and practice of photometry, calorimetry, and pyrometry; full details of apparatus employed to be given.
>
> Gas lighting. High and low grade gases. Illuminating power. Flame temperature. Specific heats. Air supply. Incandescent lighting, theory and practice. Intensified lighting. Burners and apparatus.
>
> Gas in competition for light, heat, and power.
>
> Flow of gas in mains, theory and practice; high pressure distribution.

These questions form a very fair basis for the man on the works, and without knowledge on all these points the gas manager, even though he take no part or lot in the actual distribution and supply of gas to the consumer, would be very imperfectly informed and certainly not qualified for his

position. In this article matters connected with the manufacture and production of gas, are not considered, being foreign to the intention of dealing with the education of those engaged in the uses of artificial light.

Turning now to the quite recently added examination in 'Gas Supply' we find considerably more questions affecting the illuminating engineer, and the following, certainly, are all subjects with which he should be thoroughly conversant. Taking first the syllabus for the Ordinary Grade we select the following as being most deserving of attention :—

Principles and construction of gas meters, including slot and stop mechanism. Repairing, testing, and fixing of meters.

Description and size of pipes in relation to requirements. Distribution of light. Testing of installations. Anti-vibrators. Movable pendants. Simple principles of ventilation. Methods governing pressure beyond the meter.

Theory and practice of luminous and bunsen flames.

Construction of flat flame, argand, regenerative, and incandescent burners. Regulation of gas and air supply to burners. Causes and prevention of mantle breakages. Influence of shades, globes, wall-papers, &c., on light efficiency.

Types and construction of outside shop and street lanterns. Principles of windproof lanterns. Suspension brackets and lamp pillars.

We now turn to the requirements from the more advanced student; these are dealt with in the questions set for the Honours Grade. Out of eight subjects, the following four are distinctly of value to the illuminating engineer :—

Specifications for interior fittings. Principles and construction of various types of burners and plants of intensified lighting. Lighting of churches, factories, and other large buildings. Theory and practice of ventilation by gas. Lighting for special purposes, such as billiard rooms, &c. Switch or automatic lighting and extinguishing.

Efficiency of flat-flame, incandescent, and other burners. Low and high-pressure lighting. Theory, manufacture, composition, and testing of the incandescent mantle. Illuminating effect of different methods of lighting. Flame temperature. Air supply. The hygiene of gas.

Public lighting. Testing for illuminating power and illuminating effect. Influence of reflection. Advertising and illuminating devices. Automatic lamp-lighting appliances.

Gas in competition for light, heat, and power, and the chief legal obligations affecting gas supply.

These then are the chief subjects for study, but there is one almost insurmountable difficulty: How can we learn without a teacher? It is true that appended to the programme or syllabus there is a list of works of reference; but many will be of but little use to the student. The examiners also suggest at the end of the list periodicals, namely, *The Journal of Gas Lighting*, *The Gas World*, and *The Illuminating Engineer*. This is a big undertaking, and a rather expensive one for the student—expensive in the time that must be given to the perusal of even these three periodicals. The author knows full well the value of them all, and if the student could bring himself to keep a commonplace book in sections and write it up week by week, or day by day, he would have the most complete epitome of all the subjects. But life teaches us that each hour of the day brings us all the work to do for which we are paid, and it is difficult for the "brainy" young man to find time to give more than two or three hours a day to practical reading.

Then, again, many of the subjects we have drawn attention to require hours of close work in the laboratory or the photometer room. Some gas works are "well found," and, under certain restrictions, these departments might possibly be placed at the disposal of the student. But such scientific luxuries are not to be found in all gas works.

Now what is required is the help of thoroughly practical lecturers who could give courses of lectures in certain districts, these might possibly be associated with the local technical schools.

This is done abroad. For instance, mention may be made of some most interesting particulars of the work done, in association with the Education Committee of the German Association of Gas and Water Engineers.

At Carlsruhe they have opened a research station which cost close upon £5,500, and of that amount £3,683 was contributed by the owners of gas

undertakings. Many of the manufacturing firms interested in gas production gave offerings in kind: mantles, burners, lamps, self-lighting appliances, governors, globes, instruments for testing the components and heating value of gas, instruments for measuring high temperatures, &c. In order to equip the station tests were made of the conditions of gas, water gas, and mixed gas; problems of room-lighting by inverted incandescent gas lamps as against the new metallic filament incandescent electric lamps, the relative cost being standardized; these and many other matters for the common good have been carried out by the executive of the research station at Carlsruhe.

Münich has also been busy in much the same direction, and is taking very active measures to educate the workmen employed at the several gas works.

In Dessau, under the German Continental Gas Association, a foreman's school has been in existence for ten years; during the last year seventy-five students entered, and many of these obtained remunerative appointments.

In Bremen some fifty pupils have passed through the school, receiving both theoretical and practical instruction, particularly in gas distribution and supply; such subjects as the general properties and applications of gas, leakages, services, meters, regulators, lighting systems, burners, &c., all being handled during the course.

At Carlsruhe the training of students as lighting or illuminating engineers, receives very close attention. The course comprises eight terms' attendance at the High School; a thorough grounding is given in chemistry, mathematics, machine construction, and electrical engineering; the aim of the course being original work and the "Mecca," the diploma of Doctor in Engineering. Students who have completed the machinery course are encouraged to turn their attention to illumination, and take a supplementary course of two terms for the study of chemical technology, practical testing, and technical work immediately concerned with gas lighting. Dr. Eitner lectures two hours a week on technical analysis. There are four hours' laboratory practise on the technology of gas lighting. Dr. Bunte also lectures on gas lighting, and devotes four hours to the laboratory work, which includes such subjects as gas analysis, photometry, calorimetry, carburetting methods, brilliancy of flame, &c.

Enough has been said to show that advances are being made in Germany, and signs are not wanting that much will be done in the near future in this country. Reference has been made to the work of the City and Guilds of London Institute. *The Journal of Gas Lighting* has recently published two comprehensive articles upon 'Examinations in Gas Supply,' the author giving ideal answers to certain past questions that have been set. The perusal of these articles by intending students will be most helpful and encouraging. The splendid work done by the Gas Light and Coke Company, and the lectures established by them for the training of their distribution staff, must also not be overlooked. The South Metropolitan Gas Company, again, have their own educational department, and so have many gas undertakings throughout the kingdom.

What, then, are the conclusions to be arrived at—First, that the man who intends to practise as an illuminating engineer must have a thorough knowledge of gas manufacture, distribution, and supply. That he must also have the ability to test and analyze gas, be able to use the photometer in its many forms, to prepare specifications of the points of light required for a given area; the best method and system of lighting to be adopted, the aggregation of illumination, and the quantity of gas to be consumed by the system adopted.

There is, no doubt, a great future for the illuminating engineer, though how far he will be disassociated from the gas engineer in matters connected with illumination by gas we cannot venture to predict; but it is certain that engineers and managers of gas works must have a sound knowledge, both practical and theoretical, of the science of illumination.

Demonstrations of the Use of Holophane Reflectors for Shop-Lighting.

We were recently invited to inspect the exhibition of the use of Holophane diffusing globes and reflectors for show-window lighting at Messrs. Julius Sax & Co. in Charing Cross Road, to whom we are indebted for the use of the photograph of the illustration appearing on the following page.

Several features in this exhibit seem to deserve special commendation, in that they show very clearly the advantage of using light for specific purposes, and restricting it to directions in which it can be usefully applied.



Fig. 1.

Attention may first be drawn to the method of illuminating the contents of the window as a whole. This is achieved by a row of metallic filament lamps equipped with holophane concentrating reflectors, by the aid of which the light is mainly thrown down upon the contents of the window without the actual lamps being visible to the eyes of those on the pavement. In addition to this, however, a certain amount of light is allowed to escape sideways and illuminate the sign screening them; the sign thus serves the double purpose of protecting the eyes of the observer and an advertisement.

The diffusing effect of the globes is also clearly shown by the actual contents of the windows, which contain naked lights side by side with corresponding lamps placed inside holophane fixtures, and the absence of

glare and better distribution of light resulting is made manifest by alternately turning on one system or the other. An example of a neat combined diffusing bowl and reflector is shown in Fig. 2. Another point of interest is the inclusion of coloured lamps within some of the globes in the left-hand window. These are turned on and off at intervals, and are, of course, mainly intended to attract attention. Incidentally, however, they bring out the scientific method of distribution of light adopted in this type of fixture very clearly, for the appearance of the globes containing red and green lamps, and the resultant distribution of illumination, are just as satisfactory as in the case of those containing ordinary white lamps, a result that could hardly be anticipated in the case of globes in which the crystals had been moulded in a haphazard manner. The holophane glassware has been particularly devised on scientific principles.

Yet another apparatus for the demonstration of the use of concentrating reflectors is to be seen in the left-hand window. It merely consists of a partitioned box. In the partition to the right is placed a naked tungsten lamp with no reflector; in the left partition the same type of lamp is fixed, but in this case carries a holophane concentrating reflector. Although the lamps yield roughly the same candle-power, the resultant illumination on a piece of paper placed in the base of the divisions is very striking—perhaps even more so, in fact, than the illustration suggests.

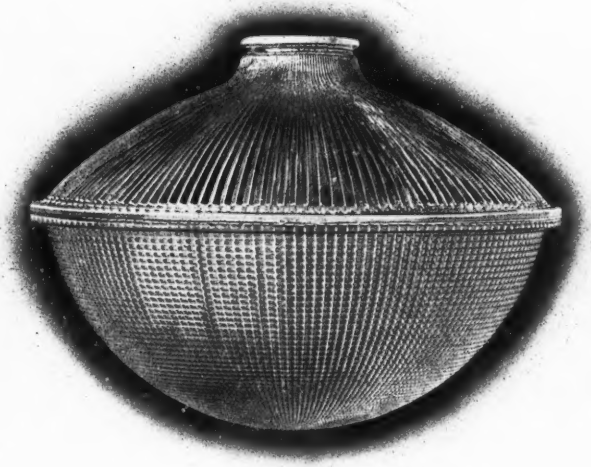


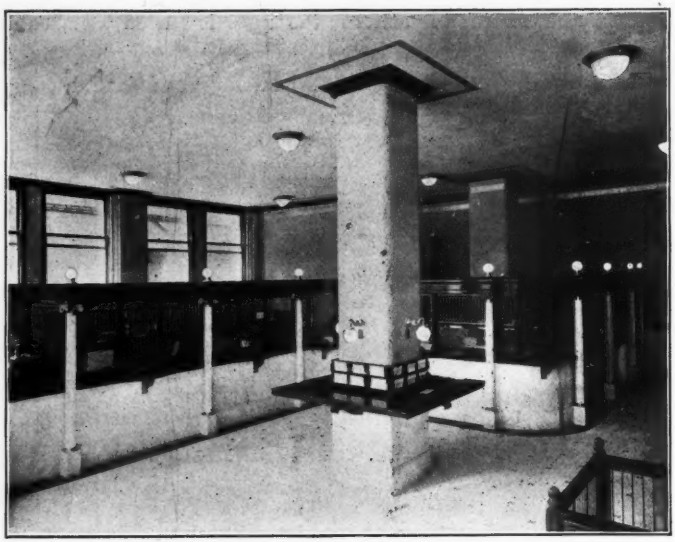
FIG. 2.

Too Vivid Illuminated Signs.

ACCORDING to *The Westminster Gazette* the National Society for Checking the Abuses of Public Advertising are getting up a memorial objecting to the erection of illuminated signs of abnormal size and brilliancy along the Thames Embankment, and a conference at the L.C.C. is about to discuss the whole question very shortly.

Illumination of a Chicago Bank by means of Holophane Reflectors.

THE illustration shows the method of illumination by Holophane diffusing shades, of the Jackson Trust and Savings Bank, Chicago. The hemispherical fixtures distributed over the ceiling serve to produce the desired uniform illumination, without glare, over the floor-area, and in addition, it will be seen that local shades serve to concentrate light over the counters, &c., where business is actually transacted.



Jackson Trust and Savings Bank, Chicago.

A Method of Tracing Daylight Illumination.

A RECENT number of *Annalen der Elektrotechnik* contains a reference to a method of studying and recording the intensity of daylight illumination which, it is suggested, might be of service in researches in school rooms, &c. The daylight illumination merely plays upon a selenium cell, which is placed in series with a suitable source of E.M.F. and a recording milliam peremeter.

The alterations in the resistance of the cell with varying illumination causes a curve to be traced out, which, it is claimed, is a serviceable indication of the strength of the illumination.

As an illustration of the use of the method a curve showing the recorded variation in the light during the solar eclipse on Aug. 31st, 1905, as observed in Algiers, is exhibited.

The initial illumination due to the unobscured sun reached 75,000 lux, but this, at total eclipse, was reduced to about 5 lux only.

Whatever be the merits of the selenium cell as an absolute light-measurer, its applicability for *comparative* measurements of illumination, and especially as a means of easily obtaining permanent records of defective conditions, deserves very careful attention.

The Absorption of Arc-Lamp Globes.

By J. T. Morris, M.I.E.E., and J. G. Farrow, B.Sc.

The amount of light cut off or absorbed by various globes used with arc-lamps varies greatly, and from the discussion of the subject in the columns of *The Illuminating Engineer* it is obvious that widely differing opinions are held.

In an article by one of us on 'Tests on Recent Flame Arcs,' which gave rise to this discussion, the measurement of the absorption of the arc-lamp globes was only a side issue, and could, therefore, receive but cursory attention.

The tests about to be described were made with the object of accurately determining the light absorbed during its passage through the globes, and also ascertaining the difference in absorption by the same globe of the light of arcs of different colours.

Short Discussion of Previous Work.—The work of Dr. Sumpner in 1893, of Messrs. Guthrie and Reidhead in 1894, of Messrs. Westerdale and Prentice in 1906, and of Dr. Marchant, has been consulted; and the opinions of Dr. Marchant and Mr. Denman Jones, as expressed in the 'Correspondence' columns of this journal, have likewise been carefully considered. These reveal great diversity in the values obtained, ranging from absorptions of 90 per cent or more, down to values of 2 per cent and even 0·0 per cent! In view of these discrepancies, the authors considered it essential to be able to repeat any given test on another day, having confidence that the result obtained would agree with the previous measurement to within some three or 4 per cent. That these conditions have been realized is proved by the results shown in Figs. 1 and 1A, Figs. 2 and 2A, and tabulated in Table I.

Method.—The carbons were arranged axially one above the other on an extension of a hand-feed lamp, so that the arc itself was some 2 ft. above the pinion which was used for controlling the length of the arc. The image of the arc was projected upon a screen close at hand, and by means of this arrangement the arc was maintained constant in length throughout each test. For convenience in adjusting the arc and handling the globes, the positive carbon was placed below the negative.

It was then possible to lower any one of the globes in an inverted position over the arc without altering its performance in any way. Only those globes were tested which allowed the free passage of air right through them, the metal cups at the bottom of some of the globes tested (which are used to regulate the air supply or for other purposes) being removed in order to facilitate the circulation of air.

There is, therefore, good reason to believe that the distribution and intensity of light from the arc itself was unaffected by the presence of the globe.

In practically every case the observations of candle-power were made at every 5 degrees; each test made under new conditions was repeated on another day, and if the agreement between these two tests was not sufficiently close a third test was instituted. In the photometric observations the sum of two beams was measured—these beams being taken from opposite sides of the arc, and making equal angles from the top carbon—this arrangement minimizing any irregularities due to wandering of the arc.

Errors due to the fact that an opal globe is not a point source of light have been practically eliminated by working with the arc at a considerable distance [some 22 ft.] from the photometer.

Particulars of Arcs employed.—The first set of tests were carried out with ordinary carbons of the open lamp type, the positive being 18 mm. in diameter with a 4 mm. core (style:

TABLE I.

Description of Globe.	Ordinary Carbons.				Flame Carbons.				+ Flame Per Cent – Ordinary Per Cent	Previous Results Per Cent
	Date.	M.S.C.P.	Per Cent Loss.	Average Per Cent Loss.	Date.	M.S.C.P.	Per Cent Loss.	Average Per Cent Loss.		
Naked Arc	1/10/08 7/10/08 17/10/08	436 423 434			3/11/08 16/11/08 18/11/08	896 886 915				
Clear Glass (13 inch)	2/10/08 12/10/08 13/10/08	368 373 364	14·6 13·5 15·5	14·5	29/10/08 2/11/08 17/11/08	741 776 779	17·5 13·6 13·4	14·8	+0·3	9
Slightly Opalescent (11 inch) ...	9/10/08 14/10/08	362 367	16·0 14·8	15·5	31/10/08 3/11/08	681 688	24·2 23·5	23·8	+8 3	27
Small Opal (8 inch)	12/10/08 14/10/08	350 354	18·7 17·8	18·2	30/10/08 3/11/08	744 746	17·3 17·0	17·2	–1·0	16
Large Opal (16 inch)	13/10/08 19/10/08	312 319	27·6 26·0	26·8	2/11/08 17/11 08	604 624	32·8 30·6	31·7	+4·9	41

$\overline{+}$ $\overline{+}$ —Fabius Henrion Nancy—608), and the negative 11 mm. in diameter and solid (style: —C. Conradty Nuernberg—Marke, C—). A pressure across the carbons of 55 volts was required to maintain a steady current of 8 amperes when the real length of the arc was adjusted to the constant working value of 4 mm.

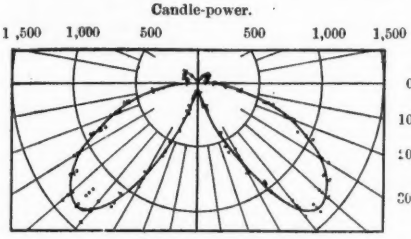


FIG. 1.—Naked Arc, Ordinary Carbons, 55 volts, 8 amps., 4 m/m.

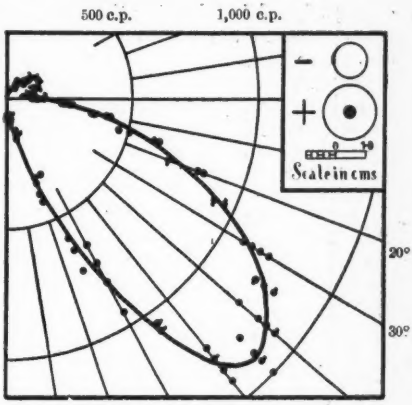


FIG. 1A.—Naked Arc, Ordinary Carbons, 55 volts, 8 amps, 4 m/m.

At a current of 8 amperes the efficiency of these carbons was practically 1·0 mean spherical candle-power per watt; but tests at their nominal current of 10 amperes would probably show a greater efficiency. Flame carbons of the brand used in the D.C. Excello lamp were used for the second set of tests, the positive being 10 mm. diameter with 4 mm. core (style: "Krone Excello," 104 C. Conradty), and the negative 9 mm. diameter with 2·5 mm. core (style: "Krone Excello," 105, C. Conradty).

The current and real length of the arc were maintained at 10 amperes and 10 mm. respectively, and 34·5 volts across the carbons were required for this purpose.

These carbons were found to have an efficiency of 2·6 mean spherical candle-power per watt at their nominal current, this figure naturally being less than that which they give when tested in the inclined position for which they are intended.

Degree of Accuracy.—Very close agreement was found to obtain between the results of separate tests made under the same conditions; especially was this the case for the tests with ordinary carbons, as may be seen by inspection

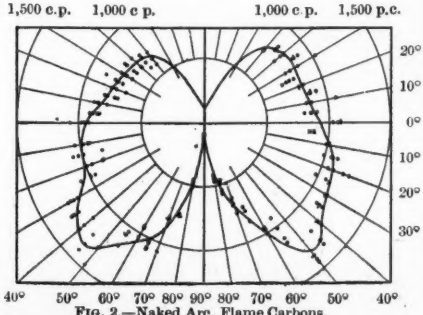


FIG. 2.—Naked Arc, Flame Carbons, 34·5 volts, 10 amps., 10 m/m.

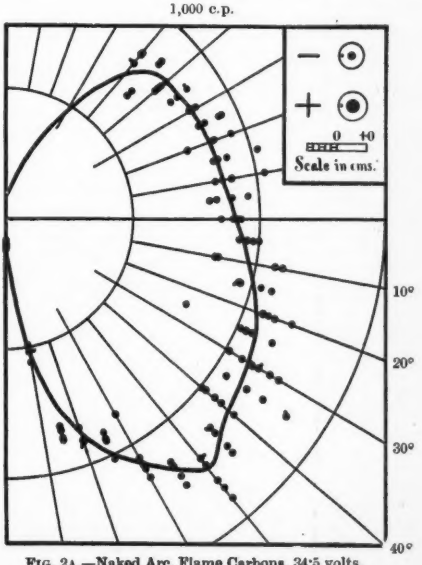


FIG. 2A.—Naked Arc, Flame Carbons, 34·5 volts, 10 amps., 10 cms.

of Figs. 1 and 1A, showing the observations made in the tests on the naked arc. The agreement obtained in the tests with flame carbons was slightly less close, because fluctuations of the flame arc itself alter the distribution of light more than those of the ordinary carbon arc. The observations taken in the tests on the naked flame arc are recorded in Figs. 2 and 2A.

From examination of the results obtained, the authors conclude that

FIG. 3.—Clear Glass Globe.

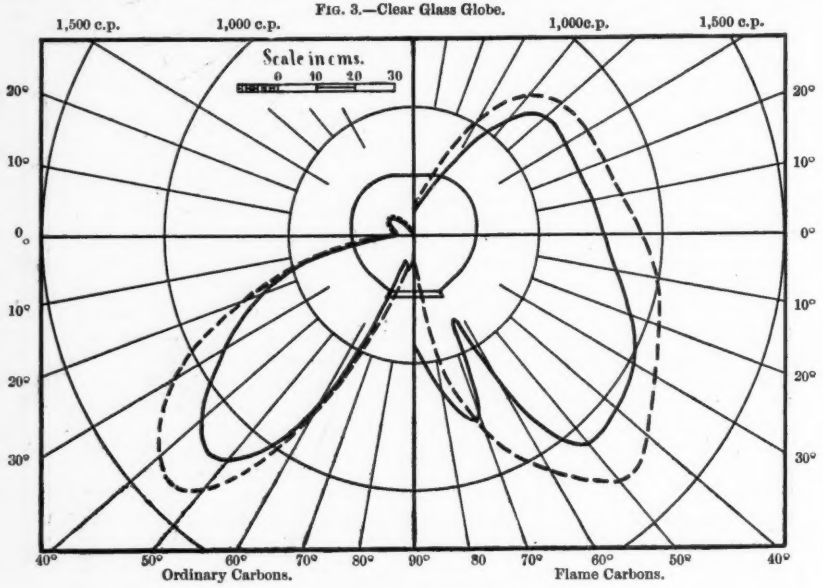
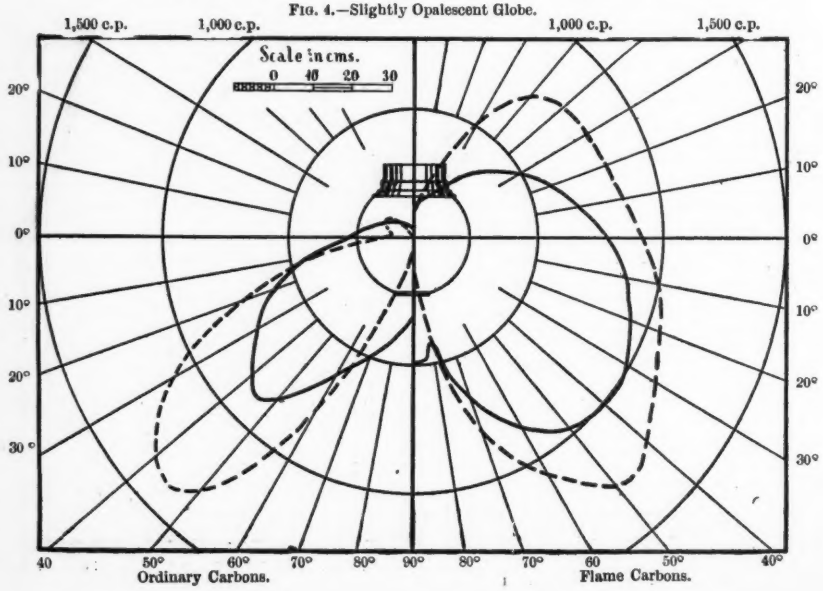


FIG. 4.—Slightly Opalescent Globe.



the mean results do not differ from the actual facts by more than 2 per cent for the ordinary carbons, and 3 per cent for the flame carbons.

Discussion of Results obtained.—Figs. 3, 4, 5, and 6 give the mean polar curves for each of the four globes tested, the left-hand side of each figure referring to the tests with ordinary carbons, whilst the right-hand side refers to those with flame carbons. For purposes of comparison the mean

FIG. 5.—Small Opal Globe.

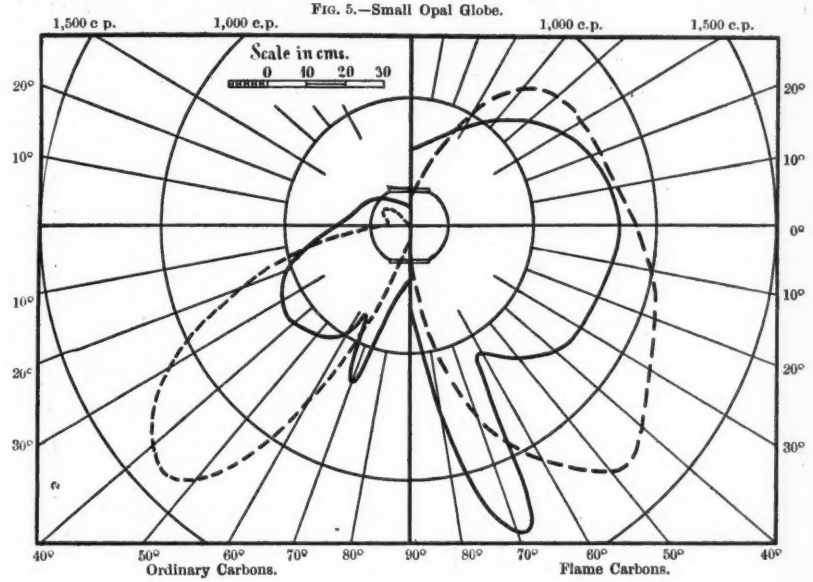
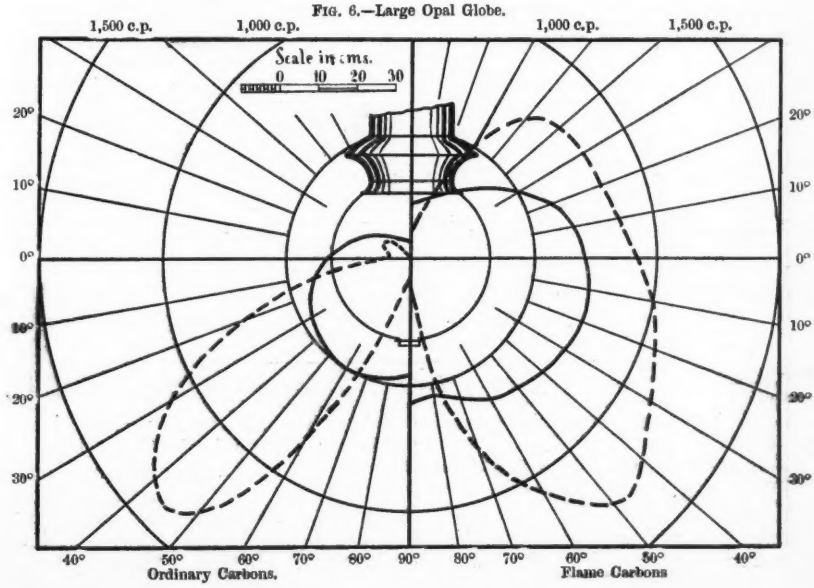


FIG. 6.—Large Opal Globe.



curves for the naked arcs are indicated by dotted lines, and the full black curves exhibit the distribution of light resulting from the addition of the globe. The outline of the globe to which each figure refers is drawn to scale in the centre of that figure.

The first globe tested (Jandus ordinary, plain glass) was from 2 to 3 mm. thick; it had a conical lower rim, and no metal fittings. It will be noticed that the obstruction of the conical rim greatly reduces the candle-power in a direction 65 degrees to 70 degrees below the horizon; whilst the candle-power in directions from 70 degrees to 90 degrees below the horizon is increased by the direct light from the arc, and light reflected from the upper surface of the globe. This globe cuts off the same percentage of blue and of yellow light.

The second globe (Excello) was of thinner glass, having a slight milky opalescence, and appearing to the eye to have greater density in its upper and lower portions than in the central zone; the metal fittings which were left in position on the upper and lower rims are shade-lined in the diagram. In the case of the irregular distribution of light from the ordinary carbons the globe becomes a source of light, and thus renders it more uniform; but the distribution from the flame carbons is rendered less uniform, because the more dense upper portion cuts off a larger percentage of light than the central zone.

The shadow cast by the narrow brass ring at the bottom of the globe is practically neutralized by diffused light from the globe itself. Blue light appears to suffer a smaller loss (16 per cent) during its passage through this globe than yellow light (24 per cent).

The third globe (Jandus flame, opal globe) was of medium and uniform density, its thickness being about 2 mm., and the rims cylindrical and equal in size; there were no metal fittings. Owing to the larger solid angle subtended by the aperture, and the fact that the globe became a source of light, the irregularities noticed in the polar curve of the clear glass globe are here accentuated. Yellow light appears to pass through this globe more readily than blue light; this fact was previously noticed during the tests for absorption by means of a glow-lamp.

The fourth globe (Crompton-Blondel) was a large opal globe having greater density than any other tested, and varying in intensity in the same way as the Excello globe described above; the aperture at the top was screened by the casing of the lamp which was left in position. This globe produced similar effects to those given by the Excello globe.

General Conclusion.—For purposes of comparison Table I. has an additional column giving results previously obtained by the incandescent lamp method. A study of these figures will reveal the fact that there are discrepancies in the earlier values ranging from 9 to 1 per cent, yet as a rapid approximation it served its purpose.

Lastly the tests recorded in the present article prove conclusively that it is impossible to determine the absorption of a globe by a single pair of measurements of the candle-power, in one direction, *i.e.*, with and without the globe; but that it is essential to determine the mean spherical candle-power for the two cases, which is a decidedly laborious piece of work unless a globe photometer be accessible.

The Third Annual Meeting of the American Gas Institute.

THE third annual meeting of the above society took place in New York on October 21st, the Presidential Address being delivered by Dr. A. C. Humphreys.

A number of papers of exceptional interest were read, including two entitled 'The Photometry of Gas' and 'Better Gas Illumination,' by Mr. C. O. Bond and T. J. Litle respectively.

Of considerable importance was the Report of the Committee on the National Unit of Light, with which we mean to deal in our next number.

Modern Arc-Lamps and their Applications.

By J. Rosemeyer,

Director of the Regina-Bogenlampen-Fabrik.

A recently issued publication of the Museum in Munich describes the progress of artificial lighting from the days of the hearth-fire, the pine-torches, the stone oil-lamp, &c., up to the intense sources of the present day.

The craving of the age for more and more light has led to the development of sources of greater and greater brilliancy, of which the modern arc-lamp is a characteristic example. This tendency towards concentration has been accompanied by a corresponding gain in efficiency. For instance, the modern electric arc-lamp, under the most favourable conditions, may consume but $\frac{1}{6}$ of a watt per Hefner, as compared with 3·5 on the part of the old carbon glow-lamps, *i.e.*, an increase in efficiency of twenty times the older value. Indeed, the development of arc-lamps alone in recent years has been so wide as to render it almost impossible for any one who is not a specialist in this field to keep himself informed of all the most recent results.

The first arc-lamp is, perhaps, to be attributed to Volta, who observed that when a current is led across two sticks of pure carbon in contact with one another, and these are subsequently withdrawn, the current continues to flow across the gap produced, thus creating an arc. The mechanism of an arc-lamp consists merely in a device to withdraw the carbons on the application of the current, and to permit a corresponding feeding together to compensate for their gradual burning away.

Yet, although it was early realized that the light from such a lamp could be increased by suitable composition of the electrodes, it was a long time before the ordinary open arc-lamp, using simple so-called pure carbons, was eventually rendered obsolete by the modern developments. Nevertheless, the old open lamp had certain obvious drawbacks. For instance, it required attention every ten hours in order to put in new carbons, it consumed too much current, its regulation was often far from perfect, and its performances were all too dependent on the nature of the carbons that happened to be used. At the recent exhibition of methods of shoplighting in Berlin no open arc-lamps of this kind were exhibited, showing clearly that they can no longer compete with modern flame-arcs and "economy" lamps (*Sparlampen*).

It was about fifteen years ago that the plan of enclosing the arc with the object of excluding the oxygen, and so prolonging the burning-life of the carbons, was generally adopted. Such lamps would burn for about 80 to 100 hours without recarboning; moreover, the slowness with which the carbons shortened enabled a very simple mechanism to be employed. The lamps were also an improvement upon the simple open-arc from the point of view of security against fire. Unlike the open-arc (taking, as a rule, about 40 volts and 10 amperes), these lamps require about 80 volts and about 5 amperes.

It was soon realized, however, that these advantages were only purchased at the cost of efficiency, for the enclosed arc consumed as much as 2·8 watts per H.K.—a value that appeared far too high in comparison with smaller sources, such as glow-lamps. This result has been so materially improved that recent tests of the Reichsanstalt on enclosed lamps gave about 1·47 watts per H.K. This was accomplished mainly by the improved design of the glass-globes,

This efficiency, however, is still too low. The exclusion of air was not sufficiently complete, with the result that the carbons burned to ash, and deposited in the form of a semi-opaque film on the globe. Apart from the loss of light so occasioned, the burning-hours are unfavourably affected by this property.

One can, indeed, secure a longer life by increasing the diameter of the carbons, and building the lamp itself on a correspondingly greater scale. The efficiency is, however, in no way improved thereby, partly because the air is still insufficiently excluded, and partly because the use of carbons

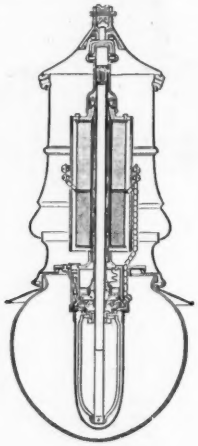


FIG. 1.
Sectional View of Regina Arc-Lamp.

of great diameter itself leads to a marked diminution in light.

Some time ago the author came to the conclusion that the efficiency of the enclosed arc could be materially improved, by excluding the oxygen more completely, and by hindering the condensation of the gases generated in the arc itself; by so doing the temperature of the arc and its surroundings are increased, and the carbons are heated to a greater distance from the incandescent tips. The adoption of this principle led to the construction of the Regina, Helia, and Reginula lamps.

In order to secure the exclusion of the air more effectually it was necessary to introduce an entirely new principle in the construction of arc-lamps, according to which the frame containing the various parts of the mechanism of the lamps, and the globe surrounding the arc, are made in one single piece which can be effectually rendered air-tight; in this way the conditions present in the ordinary type of enclosed arc-lamp, which enable the outside air to creep in, and the hot gases within the globe to escape, are avoided. By removing the cover from such a lamp the regulating magnets, carbon holders, &c., are rendered easily accessible, and the various parts are easily separable from one another.

The mechanism is also of a very simple nature, and special efforts are made to reduce wear to a minimum. Rubbing contacts and rotating spindles, &c., such as are liable to jam, are not employed. The movement of the carbons is actuated by a solenoid, fixed in the upper part of the enclosing frame, and containing an adjustable number of turns of wire, by the alteration of which the permissible strength of the current taken by the lamp can be regulated. One important consequence of the method of completely enclosing the essential parts of the lamp described is that the lamp is independent of wind and weather, and can be used in an atmosphere of acid fumes, in dusty foundries, and textile works, &c., for many years without needing readjustment.

In spite of, or in a sense, because of this very simplicity, however, several years elapsed before this method of enclosing the lamps was brought to perfection. In particular difficulties were experienced in devising a satisfactory method of leading in the current into the carbons and carbon-holders. Originally sliding contacts of various kinds were employed, and proved very unreliable. A sudden movement of the regulating lever in the lamp causes such contact-pieces to jump away, and thus to cause a momentary interruption in the current, and the temporary creation of a small arc. Naturally the repetition of these small arcs causes a roughening in the place where they originate, and this interferes with the successful leading in of the current, and

may hinder the free passage of the carbon up and down. Under such conditions the carbon "sticks," and it was a not uncommon practice in the case of the older lamps, to poke the lamp with a pole, in order to free it again.

proved ineffective. The lamp would then be sent to the works, where a mechanic would put it in order again by merely removing the excrescence where the sparking had taken place. In the Regina lamps, therefore, a patented arrangement has been in use



FIG. 2.



FIG. 3.



FIG. 4.



FIG. 5.

Types of Regina Arc-Lamps.

Such belabouring might be initially of temporary value, but frequent repetition of the process soon became necessary, and eventually, as the abrasion of the contact became accentuated, there came a time when further blows

involving the use of a flexible spiral conductor, permanently attached to the carbon, and so permitting no disturbance of contact.

The carbon-holder is also specially designed to meet the same conditions

for it enables a reliable grip of the carbon to be obtained without any rubbing contacts; as soon as the carbon has been raised the necessary amount the holder grips it with perfect security, and while the lamp is in action, maintains the arc in exactly the same condition, maintaining the current at an exactly constant value, facilitating the running of several of these lamps in series. The core attached to the upper carbon likewise swings free within the solenoid surrounding it, and executes its functions without rubbing. The mechanism also comprises an air-damper and a series-resistance, the latter built into the lamp or, in the case of the larger sizes, enclosed separately. The Regina, Helia, and Reginula lamps all utilize essentially the same mechanism and only differ in size.

An ordinary Regina lamp consumes about 0·8 watts pre mean hemispherical candle-power as compared with 1·47 watts in the case of the ordinary enclosed lamp; it utilizes carbons about 13 mm. in diameter, of homogeneous composition, and burns without attention for about 200 to 300 hours; the tests of the Reichanstalt have given 257 hours.

A Helia lamp consumes only 0·5 watts per candle, partly because thinner carbons are used, and partly because a core containing luminescing material is introduced. It is a well-known fact that the efficiency of carbons is increased by diminishing their thickness, but this result is of particular consequence in the case of enclosed arc-lamps, for which a well-defined relation exists. Within certain limits a reduction in specific consumption of $\frac{1}{100}$ of a watt per H.K. is attained for each square millimetre section that is removed from the core. In addition, by increasing the current density we secure a more stable seat for the arc and steadier burning; when the arc does not completely cover the cross-section of the carbon adjacent heated parts tend to conduct away the heat.



FIG. 6.—Illumination of Printing Office, Composing Room, Dortmund.

In the case of ordinary open arc-lamps the method of increasing the illuminating power by diminishing the cross-section of the carbons is not permissible, for by this means the short life of the carbons, amounting to only 10 hours or so, would be still further reduced; the same holds good to a less extent for enclosed arc-lamps, in which the air is only partially excluded. It is only in the case of the completely sealed-in arcs that it is possible to increase the light-efficiency without unduly reducing the life. Were one to be content with a life of only 15 to 20 hours in the case of the carbons used in the Helia lamp, a consumption of only 0·3 watts per H.K. could readily be obtained by using carbons of somewhat smaller diameter.

Six millimetre carbons (approximately 29 square mm. in cross-section) last about 40 to 60 hours in the case of the Helia lamp. An ordinary lamp would achieve this result with carbons about 9 mm. in diameter *i.e.*, about 54 sq. mm. in cross-section. Under these circumstances about twice as much carbon would be burned in the same time, and consequently a corresponding amount of ash produced, which would soon deposit upon the inner globe. Moreover, the luminous efficiency of such lamps is not satisfactory, since the specific consumption corresponding to the approximate doubling of the cross-section of the carbons would be about 0·33 watts per H.K. higher than is the case for the Helia lamp. The life of the carbons in the Helia lamp varies, according to the current employed, between 40 to 60 hours.

The Reginula lamp possesses the same main characteristics as the Helia lamp. Carbons of the same composition are employed, but somewhat shorter, and of smaller diameter to correspond with the smaller current used.

The relative advantages of these three types of lamps naturally depends upon the local conditions. When a workshop is to be illuminated, and a strong general illumination is desired, and where the works possess a generating station of their own so that current is cheap, the Regina lamp is preferable; therefore this lamp is specially stoutly constructed to meet the demands of foundries, &c., where the lamps are not infrequently subjected to rough handling. In such a case it is only necessary to insert carbons about three to four times a year.

Such lamps are specially adapted for use in those works where a large number of arc-lamps, perhaps 100 or more, are used. The inconvenient necessity for continually recarboning such a large number of lamps is avoided, and the efforts of a staff of attendants who would otherwise be constantly engaged carrying carbons about the shop can be dispensed with. Another advantage is the fact that it no longer becomes necessary to keep a large store of carbons in stock. 1,000 Regina lamps only use about 800 mks. in the year in carbons, whereas the same number of ordinary open arc-lamps would require about 20,000 mks. sterling. Reckoning half the cost of the carbons for the labour in replacing them we obtain 1,200 mks. in the case of the Regina lamps, as against 30,000 mks. in the case of the open arcs.

(*To be continued.*)

The Moral Effect of Light.

In our October number (p. 843) some remarks were published on the need of good illumination from the moral standpoint.

We notice an interesting illustration of these remarks in a recent description of the Borstall system of dealing with juvenile offenders. Good boys, it appears, are allowed to have light in their cells for half an hour longer each night, and in addition can keep pictures, photographs, &c., on their tables. This is an interesting example of the value that is attached to light, an extended period of illumination taking the form of a reward for good behaviour.

Elevated Streets in New York.

We observe in a recent number of *The Architect and Contract Reporter*, to whose courtesy we are indebted for the use of the block accompanying the reference, a note on an interesting suggestion regarding the construction of elevated streets, which is attributed to Mr. C. R. Lamb, an architect of New York.

In order to avoid the abrupt rising face of the sky-scraper, which is both open to objection from the architectural point of view, and also obscures a considerable amount of light from the street below, it is proposed to set back the front of the buildings at certain heights, thus enabling an elevated street to be contrived following the contour of that at the base of the building.



Suggested Elevated Street, New York.

The general adoption of this plan would have a very important bearing on the conditions of daylight illumination in streets, and certainly the growing height of buildings in the United States — the Singer building in New York is over 600 feet high— is bringing the question of sky-illumination into greater prominence.

Probably, too, the creation of elevated crossings of this nature would materially influence the conditions of artificial illumination, for lamps could then be permanently attached above the street below, possibly enabling lampposts to be dispensed with, and bringing the conditions more into line with those representative of indoor-illumination.

Some Notes on the Exhibits dealing with Illumination at the Berlin Exhibition of Shipbuilding and Naval Architecture.

By W. Biegon von Czudnochowski.

The first German exhibition of naval architecture was opened on June 2nd of this year in Berlin, under the management of the *Verein Deutscher Schiffswerften*, with the patronage of Royalty.

Although the exhibition was mainly devoted to the technical details of the design and equipment of vessels, mention may be made of a few exhibits which were of special interest from the standpoint of illumination. For example, attention may be drawn to the methods of lighting adopted in the saloons, &c., on the Transatlantic, East Asiatic and African lines, where a high standard of comfort and convenience is demanded. Even on the modern man-of-war the degree of illumination required is very different from that which would have been considered ample in the days of Nelson.

Thus J. D. Heymann of Hamburg exhibited a model of an oval reception-room, executed in the "Empire" style, as adopted on the Hamburg-American line. The daylight illumination of this room was provided by a central skylight round which were four niches.

The artificial illumination was provided by twenty glow-lamps grouped round the skylight and seven portable lamps distributed on the tables in the room.

Again, the Hamburg-South-American Line show a nursery, receiving daylight-illumination from a skylight of painted glass, and artificial illumination from a series of glow-lamps, some distributed on the walls and ceiling and others above this diffusing skylight.

Equally elaborate is the illumination of a smoking-room on the African line, which is wainscoted in marble.

Of special interest, again, are the suites of "State" and "Emperor" rooms, as arranged on the Norddeutsche-Lloyd boat, George Washington. The former presents a combined bath and bed room, the second a drawing-room, breakfast-room, and bedroom, done in the "Biedermeier" style. In both cases glow-lamps are mounted upon a white ceiling, and there are also lamps let into niches in the walls which are covered with diffusing glass.

In considering the interior lighting of a warship the decorative aspects of illumination are of minor importance; it is only essential to provide a good, steady illumination, satisfactory from the hygienic point of view, by as simple means as possible.

The rooms exhibited include a berth for ten lieutenants, the captain's rooms, and part of the hospital and dispensary on the new 15,000 ton cruiser Blücher, and the operating room of the 18,000 ton battleship Nassau.

In all the exhibits, however, certain general principles prevail. A uniform illumination and absence of shadows and glare is essential, and therefore in most cases a considerable number of small sources, distributed over an extensive area, are employed, clusters of lamps of concentrated brilliancy being avoided. It is also the invariable custom to abstain from using hanging fittings liable to be displaced by the motion of the ship.

Naturally the various types of metallic filament lamps now on the market (see *The Illuminating Engineer*, pp. 586–590), occupy a prominent position. On a steamboat the greater efficiency of these lamps has proved a great convenience, for in this case

the pressure of supply adopted can be specially selected to suit the lamps, so that the full benefit can be derived from their use. Thus in many cases, as, for example, on the H.A.P.A.G. boats Pennsylvania, Pretoria, Patricia, and Great Waldersee, it has been found that a single dynamo of given output sufficed where three were formerly necessary. Moreover, a great drawback to the use of metallic filament lamps on board ship has been removed by the manufacture of lamps capable of being burnt in any position.

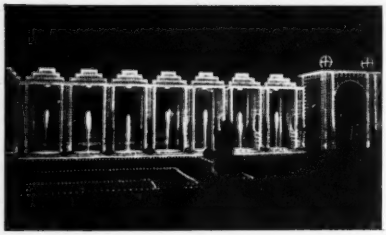


FIG. 1.—Scheme of Illuminating Gardens at Berlin Shipbuilding Exhibition.

Glow-lamps are also extremely effective for decorative and spectacular lighting, *e.g.*, for regattas, fêtes, &c. For such purposes the A.E.G. have brought out special metallic strips equipped with 8 or 16 equidistant miniature water-tight holders, connected in series so as to carry a series of 14 volt 2 H.K. lamps. This strip is cheap and convenient for outline work. Such strips are also employed for the purpose of outlining flower-beds, &c. In the small garden attached to the exhibition 35,000 small lamps are utilized for decorative effects in this way. Fig. 1 shows some such decorative effects, including a series of fountains illuminated by high-voltage, inclined carbon arc-lamps. In this case a pleasing colour contrast was obtained by utilizing white light for the fountains and glow-lamps giving a yellow light for outline purposes.

The use of the arc-lamp on board ships is practically confined to a single important application, namely searchlights. The exhibit of the *Reichs-Marine-Amt*, for example, illustrates the use of searchlights on battleships, gunboats, and even torpedo-boats. Searchlights are, however, an important adjunct even in the merchant service. For instance, they are utilized by ships passing through the Suez Canal to distinguish the various landmarks, buoys, &c.

Among the exhibits of this class may be mentioned those of the Siemens-Schukert-Werke, who utilize the method of making truly parabolic mirrors invented by Prof. Munker of Würnberg in 1886. A special form of searchlight designed in co-operation with the Prussian Department for Public Works, and credited with 75,000,000 H.K., is also exhibited by the firm J. Pintsch. The same firm exhibits lamps for lighthouse, beacon, and buoy illumination, burning compressed oil-gas, petrol, alcohol, and electric glow-lamps. Special mention may also be made of the automatic apparatus of this firm, depending upon the use of selenium, whereby lanterns are automatically lighted when darkness falls, and subsequently extinguished in the daytime.

Lastly, mention may be made of the automatic copying apparatus for the production of photographic prints of the Neue Photographische Gesellschaft of Berlin and other firms. Some of these devices employ high-voltage enclosed arc-lamps, others Cooper-Hewitt mercury-vapour lamps. In any case the sensitive paper, superimposed over the tracing from which the print is to be made, is caused to pass at a uniform rate over a glass cylinder within which the source of light is placed, so that each part is exposed to the region of greatest intensity in turn. By using a series of tracings, joined end to end, we can arrange to print off, automatically, a large number of separate drawings in turn. Or, by joining the ends of a single tracing together and mounting round the cylinder, we can print off a number of duplicates of the same diagram.

SPECIAL SECTION.

The Second Annual Convention of the Illuminating Engineering Society (*continued*).

PRESIDENTIAL ADDRESS.

By Dr. Louis Bell.

(Delivered at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1908).

I need hardly say that it gives me great pleasure to meet the Society at this Second Annual Convention. But it is not for the purpose of obvious congratulations on the gathering that I arise now, but rather for the purpose, if I may put it so boldly, of bringing before you reasons for repeating the cry of Ajax for "more light."

Unfortunately we, in these times, can only call for more light—we have not the privilege of Joshua in holding the sun and moon still to provide it for us. Things were done in a better way in the olden times, they have always said.

The topic which I wish to bring before the Convention definitely, then, is the topic of street-lighting: some of the things which underlie it, some of the things which are needed to make it sound in practice as well as in theory.

Man is becoming more and more a nocturnal animal. It was not more than two hundred odd years ago, perhaps, about the time that Philadelphia was founded or a little later, that the first attempts at systematic street-lighting were made. One has but to consult the evidences of old books and old prints to see very plainly that our ancestors and contemporaries of the founders of Philadelphia had very little to show in the way of public lighting. A candle flickering in the wind near a window, the horn lantern casting a feeble glimmer down the street and dribbling oil on the passers-by, and the pine torch or a flambeau with asphaltum, borne by a torchbearer hurrying through the crowd, and thrusting his smoky weapon in the face of the passers by—these were about all that the world could boast of two hundred or two hundred and fifty years ago in the way of street-lighting.

The activities of men are so far transferred from day to night, at the present time, that it becomes absolutely necessary to make provision for those who are travelling about after nightfall, and for the general business that is carried on at night—business of the theatres and concerts, and business of people hurrying from one place to another in the ordinary routine of their day's work extending until after sunset. For all of these purposes light, and plenty of it, is necessary, but this light we have to a rather limited extent in most cities.

The fundamental criticism against most attempts at street-lighting lies, not in the illuminants used, nor in their application, so much as in an improper adjustment of the illumination to the needs of the city. Street-lighting has been a growth and an evolution, but like all growths, it has proceeded to a certain extent along the lines of least resistance. Lamps were put, not in the best places for them, but where they can be put in with the least disturbance to individuals.

The result is, that looking over a city, particularly an American city,

however good the intention of the city government, however excellent the technical skill of those who furnish the light, much is still left to be desired. The difficulty lies in the fact that we spread out our illumination too thinly, so to speak. We do not carefully discriminate between streets, the nature of the usage of which demands considerable light, and those streets which are perfectly well lighted with a much less quantity of light. We attempt to follow out a general American theory that all men and all things are free and equal, and distribute a very finite amount of light over a very large area, with some approximation to uniformity, lest we hurt the feelings of our good fellow-citizens by insinuating that Z street does not carry the heavy traffic, and is not so crowded with by-passers in the evening as A street—in point of fact, we all know in going through a city that there are certain great avenues of evening traffic, certain places where light is needed all night, and every night, and a great deal of it. The commonest failure is the failure to recognize this simple fact of attempting a certain degree of uniformity, never exactly uniformity, of course, which is quite improper when one considers the use to which the various streets are put.

There should be what there generally is not—a very careful adjustment of the resources of the city in the matter of public lighting, so as to convenience the greatest amount of the evening traffic possible. That means in streets which are largely used during the evening, illumination commensurate with their importance should be used, but for streets where the night traffic is light, and where passers-by are few, —such a street only needs light enough to enable people to get about comfortably. There is still a third class of street which needs individual treatment, sometimes gets it and sometimes does not, and that is the outlying street, the merely suburban road, the country road which comes within the province of the municipality to illuminate. In places of that sort funds are seldom available for making anything like serious illumination, but a great deal for the convenience of the public can be done.

The purpose, the fundamental purpose of lights in these outlying, little-used streets, which yet need some light, is merely to serve as markers of the way; in other words, in these unfrequented places, streets where illumination of the first order is unnecessary, and that of the second order needlessly great, the important thing is to so distribute the light that the illuminants serve to mark the way and clear the passage for the passers-by. In such places the somewhat common practice of using very large units of whatever kind is obviously improper. One marker a mile of 10,000 candle-power is not anywhere nearly so good as half the amount of light put out at short distances in smaller units; in other words, where you are using a light merely as a marker to show the way, clear the way for driving or motor-cars or pedestrians, and cannot undertake a general illumination, the next best thing is to go to small units and locate them so as to get the best results obtainable from the energy in whatever way it may be applied.

There are three distinct classes of streets which have to be considered in taking up the problem of the theoretical character and practically useful illumination. First, there are the chief streets, the heavy arteries of traffic which need all the light they can get. Then there are the secondary streets, making up the bulk of an ordinary city, which need to be well-lighted, but do not require a blaze of illumination, because they are used in an entirely different way from the main streets. And, finally, the tertiary streets, in which the lighting is practically merely to show the way.

In our ordinary practice here these classes run into each other by such gradual transitions that one can hardly tell whether there was any fundamental idea in the minds of the persons who laid out the streets or not. Our chief streets, as a rule, all over the country, are really poorly lighted, the secondary streets not particularly well-lighted—sometimes a little better than they should be, and sometimes not quite

so well—and the tertiary streets frequently rejoice only in one illuminant every long block, utterly useless for practical purposes except within a very short radius, and utterly failing, too, in the proper marking out of the way. As regards the absolute amount of light required there will be always a great difference of opinion. In the principal streets where the traffic is constantly heavy, I do not think that one would go far wrong in following the principle that one should have light enough to see to read a paper by at a pinch. I would not recommend the citizens to sit out on the curb and read their evening papers, but I think the chief streets of the city should be always so well lighted that if any one has to consult a notebook to find his way, or wants to take out a letter and consult it for any purpose, he should be able to read it without having to walk a half block to get under the nearest light. As to the secondary streets, much less amount of light than that is desirable, and not so much is necessary, in fact. The tertiary streets can carry a still less amount.

In connexion with this matter I may say that the foreign practice in England and on the Continent is to provide in the different streets light enough to read a paper by. This summer I travelled miles through the chief streets of the European cities, and was able to read very fine print in the Baedecker every step of the way by the light of the street lights alone. That is the ordinary standard of goodness which is lived up to in the large foreign centres. In the secondary streets we want merely plenty of light to go about with, and in the tertiary streets merely enough to see the way.

In actual amount the London canon in lighting calls for an average of something like a quarter of a foot-candle, as against our one-tenth, one-eighth, or one-quarter that amount in the ordinary American city. The secondary streets on the other side are about down to the illumination of the ordinary street here. The tertiary streets are still less lighted, perhaps half as much, but the light is invariably secured by comparatively small units, either gas or electric, instead of putting up very big units either gas or electric. So much for the general arrangement, and the general design of the illumination.

Now as to its manner. In the first place, whatever the intensity adopted, it is desirable to have a fairly uniform distribution. By that I do not mean uniformity at the expense of low maxima, but it is undesirable so to scatter one's lights as to have a great deal of light here and there and none between. Secondly, it is desirable to diffuse that light so as to make it as useful as possible. One of the great points of difference between the practice here and European practice is that diffusing globes are practically in universal use except in the United States, and therefore there is less uniform lighting here than almost anywhere else. Merely, if for no other reason, because the light is not diffused, the radiants themselves are of a different character, are intensely brilliant, and the result is a certain dazzling effect which very much decreases the practical usefulness of the light, on just the same principle that a bare lamp-post out in front of your eyes is a very inconvenient thing by which to read.

In the matter of distribution one cannot sacrifice too much for the sake of uniformity. It is a fact which one will find out readily by observation that you can light a street uniformly and yet badly. You can have a fairly good minimum on a street, and yet lighted badly for the purposes of a chief street. I can best instance that by mentioning two places which I have looked at, which point the moral very distinctly. One is a place in Paris where there is a tremendous concentration of illuminants. They are all small units and massed together, massed in a way that would show, if you deliberately sat down and figured the illumination, a result which would cause you to feel proud of it. Practically, however, the place is badly lighted. There is no effect of brilliancy; you can see fairly well all over, but as a place for a public circuit and avenue of traffic the thing is insufficiently lighted.

I call to mind another place in Berlin where the average intensity is probably

not very much higher, not more than 50 per cent, perhaps, where the units used are of the same kind, but of very much greater intensity; the effect is beautiful. In other words, one cannot dwell either on the minimum in the street as a canon of good lighting, nor on the average as you see it along the street. You must bear in mind that a big bunch of light, throwing an immense amount of light out into the street, and being reflected from the house, adds a great deal to the efficient illumination of that street for the purpose for which we want street illumination. You can get fair uniform lighting, and you can take the same amount of energy and get less uniform lighting which will be quite as effective. In other words, you must look at the thing as a practical matter, and not as a mere theoretical matter of so many hundreds of a foot-candle. It does not take an expert in illumination to see whether a street is badly lighted or not, and it does not, consequently, take an illuminometer, with a measurement of the thousandths foot candle-power to find the half-way distance between lamps, to show that improvements are necessary. The thing is a strictly practical matter, and should be treated as such.

That brings up the question of the direction of measurement. How shall we measure the lights on the street? The customary measurement here is a tacit apology for bad lighting. The customary method of measuring here is a measurement practically half-way between the lamps with a disc, or other measuring instrument held normal to the latter. If one gauges his illumination solely by such readings as this, he can be guaranteed of a mighty badly lighted street in every case, because the tendency of competition, from whatever source it comes, is to secure that minimum at as low a maximum as possible, modifying the illuminant to be as badly as they can, subject to the condition of getting the low minimum, and the result is a badly lighted street. I could mention types of illuminants which have been deliberately specialized for the purpose of giving two-hundredths or three-hundredths of a candle-foot, at some point down the street, where, if the same illuminant was taken and designed, not to give a special form of illumination, but to give the best efficiency it was capable, it would not only be possible to make it light the distant parts of the street, but the whole of the street; in other words, there are cases in which the efficiency is deliberately sacrificed for the sake of what is nothing more or less than bad distribution.

Every effort toward economy should be an effort directed to increase the total flux of light, because, with our modern illuminants, there is this to be taken into consideration for street-lighting, at least, the intrinsic brilliancy is so high that some diffusion is necessary, and they are all of a character—all the modern ones—which permit you, in getting diffusion, to get redistribution if you want it.

There is no excuse, therefore, to-day, whatever there may have been ten years ago, for specializing distributions by means of design of the illuminant, because, at the present time, we must shield them. We can both distribute and diffuse at the same time if we want to, and, what is more important, when you light a street on any adequate scale you need all the spherical distribution you can get.

The customary practice in the matter of direction of measurement, is to measure the illumination after it falls on a plane 4 ft. above the ground, or at some other specified height, in any case measuring the resolved component on a horizontal plane. One-tenth of a foot-candle so measured means a great deal more than the tenth which we get on the normal system of testing.

One is sometimes tempted to wonder on what basis this particular measurement was chosen, and why the thing has not been more fully discussed. It has not been more fully discussed here because people do not like to talk about that little resolved component. It is so much nicer to talk about the normal; it is not discussed abroad with any great vigour, simply because in the first place the light is sufficient

to give a thoroughly adequate measurement that way, with the measuring of the horizontal surface; and, in the second, because, as a matter of fact—it happens to be a rather curious reason, too—the lights in England and on the Continent are customarily placed at just about the point that makes it a matter of indifference to them which way they measure; that is to say, in measuring the illumination on the horizontal plane you measure the effect from the two lights. In measuring on the normal you obviously have to measure the effect from one, because that is the only one you assume you are using.

Now, at the distance and height at which big units are customarily placed abroad, whether gas or electric, only four or five times the height of the post being taken as the distance between lamps, a double or projected measurement of one lamp became substantially identical with its normal measurement; so that it ceases to be a vital question abroad whether you use one or the other, because the two are nearly coincident. That is, we take the normal measurement with an inward apology to ourselves, after passing by the convenience, or propriety, or even technical sufficiency of adding the one rather than the other. The thing which I wish to point out is, that after you reckon on illumination on the normal, for heaven's sake give us enough of it to see something by, and not the apologetic two-hundredths or three-hundredths of a foot-candle which has been too often talked about.

This brings up the question of economy in street-lighting, and, in particular, I want to devote a brief moment of animadversion to the so-called moonlight schedule. I think this curious minimum, which we have too long followed, of a couple of hundredths of foot-candle for our illuminant units came largely from the fact that that was supposed to be about the maximum intensity of moonlight in our latitude. We say that we can read nicely by a full moon, which gives one-hundredth, to two-hundredths of a foot-candle and we will be happy. In point of fact, moonlight is diffused, diffused with a vengeance, and from my observation I should say that moonlight, on account of its diffusion, was at least two or three times as good as an equal fraction of a foot-candle delivered from an arc-light, or Welsbach, or big incandescent lamp, or what not, merely because you have in the moonlight the complete diffusion and low intrinsic brilliancy which lets the eye do its best work. You do not have any trouble driving an automobile in moonlight if you have a good headlight; you might have trouble in driving an automobile, even with a good headlight in a brilliantly-lighted street, because the lights in the street flash straight in your face, and it is that practical value of diffusion which we all recognize when it is called to our attention, and that should be recognized in street-lighting.

If you are going in for an undiffused light you must furnish more of it; where you can diffuse your light, you can fall back on low values.

The moonlight schedule, which is the favourite method of economizing, is most deceptive. In the first place, normal moonlight in our latitude is less than two-hundredths of a foot-candle. In the second place, the half-moon intensity, instead of being half as good as a full moon, is only one-tenth as good. That means that there is a large element of specular reflection in moonlight, the same as from a piece of polished cardboard. The diffusion is very imperfect, but the actual fact, from the concordant measurements of three or four astronomers, is, that a half-moon is only one-tenth of the brilliancy of the full moon, and consequently your two-hundredths of a foot-candle, or 1500 in three or four days, has sunk to an insignificant figure, and there is only one week in the month when the moonlight rays are of a magnitude to be of any particular account.

Customarily the moonlight schedule is, perhaps, two-thirds of the full all night and every night schedule; you are going to get anything like proper illumination, three-fourths, or eight-tenths, or something of that order.

A second common effort at economy is through the means of half-night

lighting. Half-night lighting from the standpoint of the needs of the public is a great deal better than the moonlight schedule, because, so far as the brilliantly lighted streets of the city are concerned, the legitimate activities of the city cease before morning, so that there is some reason in reducing the number of lights after midnight or one o'clock. If anybody has to economize rigidly, it is far better to put out every other light or something of that kind, than it is to run them on a regularly reduced moonlight schedule.

It is never desirable to go into half-night lighting or petty economies of that kind anyhow, but my purpose here is to point out that the moon is a bad thing to fall back on. If you have to cut down the illumination at certain times, from motives of economy, it is better to do it at your own time, and do it systematically than it is to depend on moonlight and weather conditions.

Now, as to the important things of the future in street-lighting. The first of them is a recognition of the fact that we are lighting the streets for people to use; that we should light the streets with reference to the use which is going to be made of them, and, on the whole, they should be much more brilliantly lighted than streets are customarily lighted in this country to-day. We need it, not only for the general purposes of the city, but for the police purposes, and there all night lighting is a very important matter. It is an old saw among electric men that an arc light is as good as a policeman. That may or may not be true in an exact sense, but it is certain that a well-lighted city, a city lighted well all over, is a safer city at night than the average poorly lighted city.

Finally, granted that the need for more light, and more light in the chief streets to a very considerable extent is admitted—two or three times as much as we have now—the next question which arises is by what means shall this need be satisfied? We are now in the transition period. As every engineer connected with the gas and electric light industry knows, the one thing which I think is perfectly safe to say, about which there can be very little doubt, is that the old illuminants, the old types of street lights, both gas and electric, have got to go, and have got to go very rapidly. The old time, glimmering arc-lamps, the faded out and worn out vertical Welsbach, both have got to go to the general scrap-heap, and go into oblivion, and they have got to do this before a very long while, and in their place we will have an entire different order of lamps, which, by increasing the efficiency, will enable the streets to be lighted as they ought to be.

We have come to a parting of the ways; we have got to turn away from our old ideals and head ourselves toward the new ones, to wit, the great god efficiency, whose worship has been too long left out of our devotion, owing to the minor deities of the engineering profession. Three or four years will work a change. The handwriting is on the wall plainly enough now for any one who cares to read it, and we are going to have, and we have got to have, and we ought, as illuminating engineers, to insist on having the kind of public lighting which has never been seen in this country except in one or two isolated spots. We need more light, better diffused and better distributed, and it is our duty, if we are to make any claims to be pioneers in the way of illuminating engineering, to keep at this subject technically and personally until we get the more light which we ought to have.

The Electrical Review, of New York, and *The Western Electrician*, of Chicago, have joined forces; the new journal is to be issued under the name of *The Electrical Review and Western Electrician*, and the address of the publishing offices will be in future 204, Dearborn Street, Chicago, U.S.A.

Discussion of Papers by Dr. A. C. Humphreys, Dr. A. H. Elliott, J. E. Woodwell, E. G. Perrot, and L. J. Lewinson.

(Papers read at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1906; abstracted in *The Illuminating Engineer* for November.)

Report of Committee on Nomenclature and Standards.

By Dr. A. C. Humphreys.

After presenting this report, in the absence of Dr. A. C. Humphreys, **Dr. Hyde** added a few remarks. He said that all were agreed, in the abstract, as to the benefits of a common standard, but the practical realization of this desire called for much labour, and he thought much credit was due to the Illuminating Engineering Society for taking the initiative, and to the American Institutions of Gas and Electrical Engineers for responding so cordially.

The attitude of the industries concerned had been most appreciative. The campaign, however, was not yet over, and he hoped the Society would continue to assist the movement in which they had taken such definite initiative.

Dr. L. Bell, the President, thought the prospects of an international standard were bright, for continental nations were most sympathetic, and seemed to feel that the time was ripe for definite movement. All that had been necessary was the starting of the work, and he felt sure the committees concerned would soon bring their labours to a successful issue.

The Illuminating Value of Petroleum Oils.

By Dr. A. H. Elliott.

Dr. L. Bell, the President, said that any experienced photometrist was aware of the value of a good flame standard for the testing of gas, for which purpose electric glow-lamps, however desirable as the custodian of the primary standard, were inconvenient. Dr. Elliott's paper deserved very full discussion.

Mr. N. W. Gifford pointed out that Dr. Elliott's standard was already widely used as a working standard.

Mr. C. O. Bond said that his experience was confined to flat-wick oil standards, and confirmed Dr. Elliott's statement that a very satisfactory light was obtained up to 10 hours. After 24 hours, however, the wick tended to char, the flame became uneven and smoked, and the chimney eventually cracked in some cases. But in any variety of lamp utilizing a wick in actual contact with the flame the same difficulties would be encountered.

Mr. C. O. Bond also pointed out that it was important, not so much that no change in candle-power should occur with time as that we should be able to know definitely how much change would take place; in his experience the change had not been regular, though Dr. Humphreys had met with more success.

Both the Hefner and Pentane lamps, though excellent in many respects, were open to practical objections, and the latter was bulky and expensive; he thought, therefore, there was an opening for a simple oil standard.

Mr. R. C. Ware asked if Dr. Elliott had tried to eliminate charring by using asbestos wicks ?

Mr. N. A. Dutton thought that a lamp would burn with little loss of efficiency for 30 or 40 hours, provided the oil was kept at the same level; otherwise the drawing power of the wick was impaired.

Dr. E. P. Hyde asked why it was necessary that a lamp intended as a secondary standard should burn with the same candle-power indefinitely. Could it not be standardized at intervals during the day?

Was it possible to reproduce such a lamp accurately, provided the same oil and the same kind of wicks were used and could a Methven screen arrangement be applied?

Mr. E. L. Elliott asked whether the change in intensity was due to a change in the size of the flame or a change in intrinsic brilliancy.

Dr. L. Bell, the President, in closing the discussion, inquired whether any advantage might be derived by the use of a convenient and cheap hydrocarbon, and whether a flat quartz plate might not replace the chimney so as to avoid danger of cracking.

In reply **Dr. A. H. Elliott** thought the use of a definite hydrocarbon was unnecessary, for hydrocarbons of widely different nature could be used with substantially the same results as regards candle-power.

Ten hours was the longest period of burning he had employed, but a New York company used reservoir lamps that burned 24 hours, and stated that the intensity only altered 0·2 to 0·3 candle-power during that time. In these particular experiments he used bare flames, unscreened in any way; however, he had had little experience of broken chimneys, and thought that the incrustation of the wick mentioned by Mr. Bond might arise through the use of a poor quality of oil.

Dr. Elliott also expressed his desire that his results might lead to publication of similar work by others working in the same field.

He agreed that the Hefner lamp was too small a unit, and the colour was a disadvantage unless one was a skilled photometrist.

The Pentane lamp was clumsy, and the quality of the pentane in the reservoir gradually changed unless constantly renewed; moreover it required constant attention, and could not be used continuously, if only on account of the cost.

The asbestos wick might be very serviceable if it could be made sufficiently loose and fluffy. He had also tried felt wicks, but they became clogged at the end; it was a regrettable tendency of most wicks eventually to get hard and banded at the end, and therefore they were invariably replaced before any marked change in quality had occurred.

The change in candle-power of an oil lamp was due to a change in the size of the flame, and the initial shape of the flame was an important factor when standardizing a lamp.

The Intrinsic Brightness of Lighting Sources.

By J. E. Woodwell.

Dr. L. Bell, in opening the discussion, remarked that he was pleased to note a direct connexion was now traced between the contraction of the pupil aperture and intrinsic brilliancy.

Mr. D. McFarlane Moore was pleased to feel that the Society was giving special attention to several matters of vital interest in illumination, such as colour and intrinsic brilliancy. The effect of intrinsic brilliancy, as opposed to distance away of the source, was illustrated by the effect of a distant arc-lamp, which, when in the field of view of the observer, spoiled the entire effect of near and local incandescent lighting. Mr. Moore referred to the low intrinsic brilliancy of the vapour tube, and said that this quality avoided the necessity for using diffusing globes, which sometimes absorbed as much as 60 per cent of the light generated. He himself found that with a Moore tube operated at about 6 Hefners per foot an excellent illumination could be secured from an apparently very dim source. At 12 Hefners per foot the intrinsic

brilliancy of the lamp approaches 1 candle-power per square inch.

Mr. Hering pointed out that when one spoke of "candle-power per square inch" of a source, projected area, as seen by the observer, was meant and not actual superficial area.

He also confirmed the suggestion that it was possible to see by the aid of a weaker illumination if there is no glaring source in the field of view.

Mr. V. R. Lansingh thought it was incorrect to assume that intrinsic brilliancy alone was the important factor; account must also be taken of the total amount of light transmitted to the eye from a source. For instance, a mercury vapour lamp, as a whole, was very trying to the eyes, on account of its high candle-power, irrespective of the fact that its intrinsic brilliancy was only 19 candle-power per square inch.

Mr. J. E. Woodwell, in reply, questioned Mr. Moore's figure of 60 per cent for the absorption of globes; it was inevitable that a certain amount of light should be lost in this way, but the results secured justified the sacrifice. But probably 25 to 30 per cent was a better estimate of the loss.

Mr. Woodwell thought that his definition of intrinsic brilliancy fell within the definition of the Geneva Congress; "intrinsic" was intended to convey information as to the actual brightness as a whole, and therefore the entire superficial surface should be taken. This, however, only affected numerical results, and not the principles for which he contended.

Mr. Woodwell admitted that further data were needed in the direction suggested by Mr. Lansingh; he thought that where there were multiple sources the effect resembled that of bird-shot, so to speak, as compared with a single bullet, and he was inclined to think that, in general, the effect might be attributed to the breaking down of adjacent cells on the retina.

Architecture and Illumination.

By E. G. Perrot.

After presenting the above paper **Mr. E. G. Perrot** added a few words referring to the general interest taken in the historic associations of Philadelphia, as illustrating the value of architecture and fine buildings as a means of recording the history of the past.

Mr. Perrot added that the illumination of the City Hall in Philadelphia was successful up to a certain point, but he thought that a little more attention was needed from the architect and illuminating engineer conjointly in order to bring out certain features of the building to the best advantage; this was typical of those instances in which the sympathetic spirit of the illuminating engineer could assist the development of illumination and architecture as well. The discussion was then opened.

Mr. A. J. Marshall agreed that the illuminating engineer and the architect ought to invite the assistance of one another, and generally co-operate in cases coming under the jurisdiction of both; but such co-operation ought to be mutual.

Mr. Marshall also doubted whether any real distinction could be drawn between "decorative" and "necessary" lighting of buildings. In any case the fixtures best adapted to the building were needed, and there was invariably some aspect of the fitness of things such as rendered architectural treatment. in a sense, necessary.

Mr. L. R. Hopton heartily endorsed Mr. Perrot's suggestion that the Society should publish details of successful work carried out by prominent architects and illuminating engineers in consultation.

Mr. J. F. Maguire was glad that Mr. Perrot regarded the selection of stock-fixtures as reprehensible, as this was a point on which he had been in controversy with some architects. It was very desirable that the architect should consult the illuminating engineer *before* his plans were fully completed; the need for early co-operation of this nature as illustrated by the case of the Engineering Societies' Building in New York, where the space allowed between the diffusing false glass ceiling and the ceiling proper proved to be only thirteen inches, with the result that the illuminating engineer could

not obtain the perfect diffusing effect desired.

It was not reasonable to expect the illuminating engineer to produce wonderful effects when plans were designed and completed irrespective of his requirements.

Mr. E. G. Perrot, in reply, agreed that the co-operation between the engineer and the architect was needed in any scheme, and he himself was by training a structural engineer as well as an architect. This same need was initially experienced, and indeed is still felt to-day by the big engineering firms who construct "sky-scrapers."

Mr. Perrot next proceeded to explain his standpoint as regards "necessary" and "decorative" lighting in greater detail, referring to certain fixtures, which, however adequate for the purpose of illumination, did not meet the architect's ideas of proportion.

The architect needed the services of the illuminating engineer badly, and if he desired to use a certain system of lighting, his right course was to inform the engineer of this fact, before his plans were complete.

It was, however, necessary for the Illuminating Engineering Society to make its influence felt by sending out information, just as the Steel Corporations originally led the architect to appreciate steel girders at a time when 75 to 80 per cent of the profession knew very little about the matter. In the same way many architects to-day only fail to appreciate the importance of illuminating engineering, because they have not yet had time and opportunity to acquire a knowledge of the work of the Society.

The Intensity of Natural Illumination throughout the Day.

By L. J. Lewinson.

Mr. Carl Hering remarked that the figures on this subject in different text-books varied considerably, and therefore such a paper as this was very valuable.

The question why the eye was apparently satisfied at night with an order of illumination so much lower than daylight was extremely interesting. Apparently the maximum daylight illumination obtained, about 12,000 foot-candles, corresponded closely with the intrinsic brilliancy of an incandescent mantle, as deduced from the figures in Dr. Bell's book. It was difficult to conceive that a piece of paper exposed to daylight could be as bright as a Welsbach mantle, but this was suggested by the available figures.

Mr. J. E. Woodwell questioned whether either the horizontal or normal components of daylight illumination were so important as the vertical. Practically all light in a room enters by vertical windows, and is then reflected from vertical walls, &c.: measurements of this component were therefore needed.

Mr. E. G. Perrot remarked on the difference in daylight conditions at different times in the year, and thought that the results of this paper could only be rigidly applied to the month of September. In fact, the design of a building from the point of view of daylight illumination might be correct at one time of the year and not at another.

Dr. L. Bell, President, in closing the discussion, commented on the loose phraseology often employed in describing daylight illumination, and explained that these investigations dealt with the actual direct rays of the sun, and not stray light that had filtered through clouds and been again reflected to and fro before reaching the place of measurement.

Mr. L. J. Lewinson, in reply, said he had not dealt with vertical illumination, because of the uncertainty as to the direction in which a vertical photometrical screen ought to face. In all cases his measurements recorded sunlight *plus* skylight.

With regard to a statement in his paper that they were unable to read the instruments by a natural illumination of 2 foot-candles he thought this must be due to the differences of the light. Probably a local concentrated value of 2 foot-candles, coupled with a very dark sky, would have enabled the instruments to be read.

Design of the Illumination of the New York City Carnegie Libraries.

By L. B. Marks.

(Paper read at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1908.)

(*Continued from p.* 932.)

RESULTS OF TESTS.

Results of tests of general illumination in all the principal working positions in the room are shown in foot-candles on the accompanying chart. The measurements were made on a horizontal plane approximately 3 ft. above the floor. The average of all values is 1–1.10 foot-candles. Data for this floor are as follows :—

First Floor.

Area, sq. ft.	2,950
Contents, c. ft.	44,950
Watts, general illumination	2,316
Watts, localized illumination	4,174
Total watts	6,490

General Illumination.

Watts per sq. ft.	0·78
Watts per c. ft.	0·05
Average foot candles on horizontal working plane	1·1
Foot-candles per watt per sq. ft. ...	1·4
Approx. spher. candle-power per sq. ft...	0·2
Approx. spher. candle-power c. ft. ...	0·012

FREE STANDING BOOK-STACKS.

Results of the vertical illumination on book-stacks are shown in foot-candles on the accompanying chart, the approximate location of the test-plate being indicated by the position of the foot-candle values on the diagram. The figures marked (*) indicate results of test obtained with the photo-

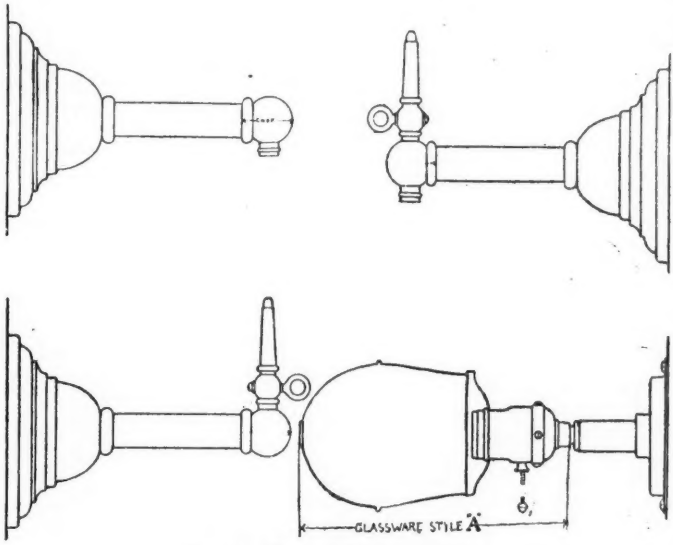


Fig. 14.—Fixtures Nos. 1, 2, 3 and 4.

meter on the shelves. Figures underlined indicate results obtained by viewing the test-plate through the photometer from the position which would probably be assumed by the average observer. This shows that a considerable difference is found when the test-plate is viewed from different angles, and when test-plates of different character are used.

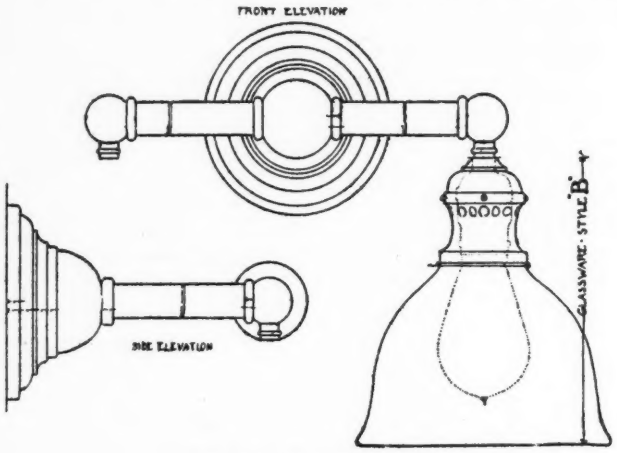


FIG. 15.—Fixture No. 5.

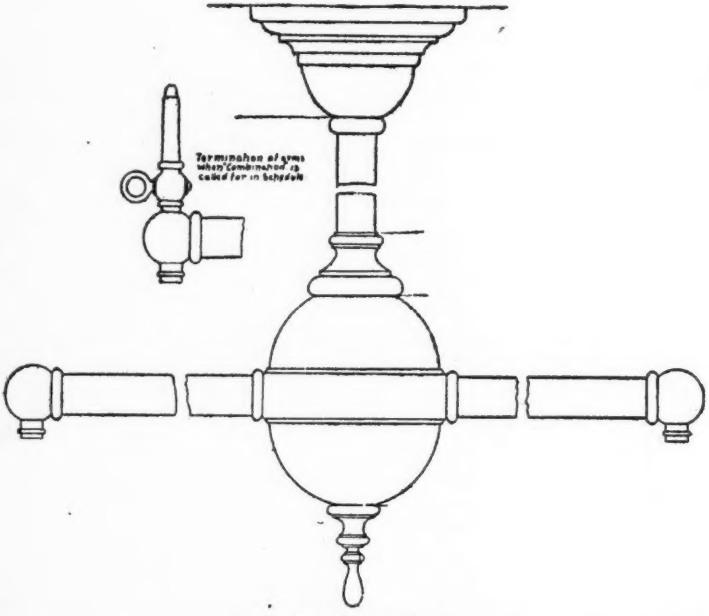


FIG. 16.—Fixture No. 6.

Tests were made to show horizontal illumination immediately in front of

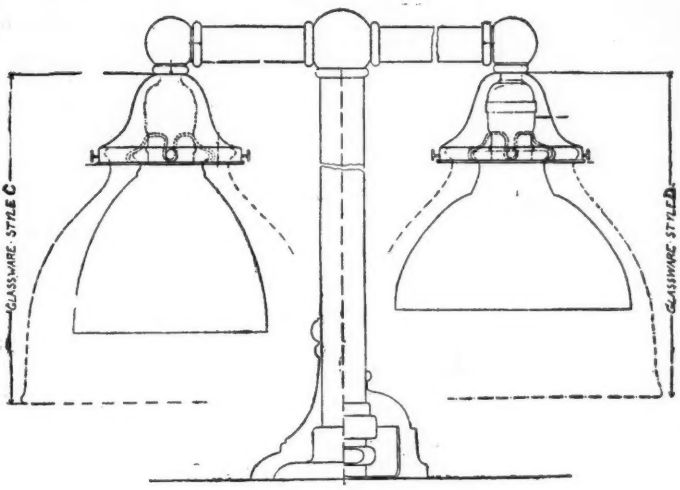


FIG. 17.—Fixtures Nos. 7L and 7R.

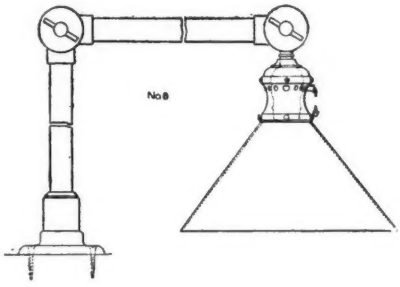
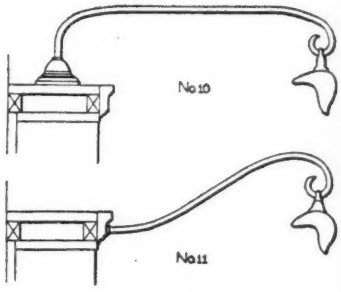


FIG. 18.—Fixture No. 8.



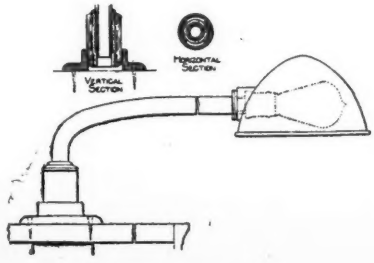


FIG. 19.—Fixture No. 9.

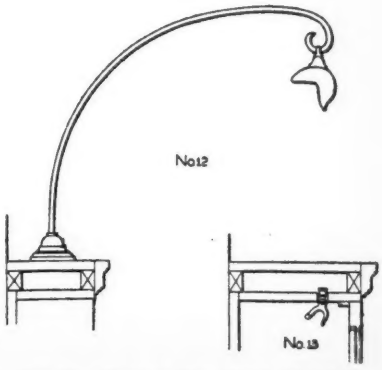


FIG. 20.—Fixtures Nos. 10, 11, 12 and 13.

the stack in position where one would be likely to hold a book removed from the racks for casual examination. The results of these tests are indicated on the diagram in figures inscribed in rectangles.

SEVEN SHELF WALL BOOKCASES.

The illumination in foot-candles, as measured on vertical white blotting paper described in the tests of the aisle book-stacks, is shown in Fig 27; the figures underlined in this illustration

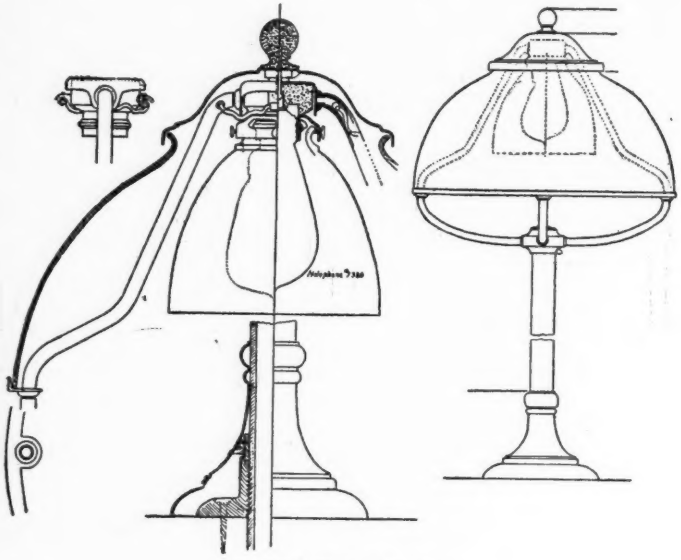


FIG. 21.—Fixture No. 14.

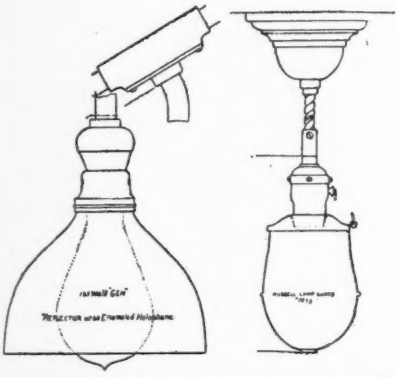


FIG. 22.—Fixtures Nos. 16 and 15.

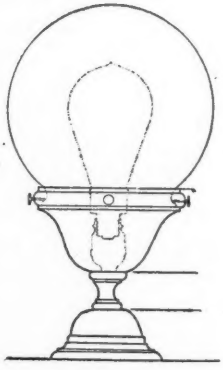


FIG. 23.—Fixture No. 17.

represent the foot-candles, and their location on the diagram indicates the location of the test-plate on the bookshelves.

As in the previous test, measurements were made to determine horizontal illumination in front of the bookshelves. These values are indicated on the diagram in figures inscribed in rectangles.

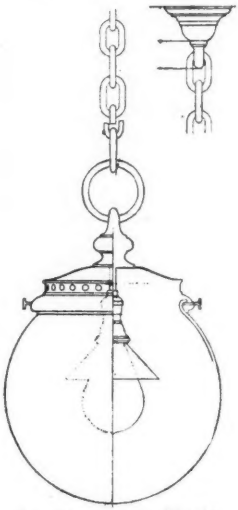


FIG. 24.—Fixture No. 18.

VERTICAL ILLUMINATION ON LOW BOOKSHELVES.

This test was conducted with a blotting-paper test-plate as described in the tests of the aisle book-stacks. The results are indicated on the diagram. The foot-candle values being placed on the diagram in such a manner as to indicate the location of the test-plate in the test.

ROUND READING-TABLES.

Test 1.—This test was made by placing the blotting-paper as a test-plate upon the surface of the table and viewing it through the photometer from the angle at which the average reader would probably view a book and receive a minimum amount of regular reflection. The foot-candles illumination, angle of view, and distance from the centre of the table to test lamp were as follows:

Distance from centre of table to test lamp.	Angle of view with the horiz.	Horizontal illumination.
6 inches	50°	7·9 ft. c.
12 inches	50°	7·5 ft. c.
18 inches	50°	7·1 ft. c.

The illustration shows a plan of this table and location of lamp and position of the test-plate.

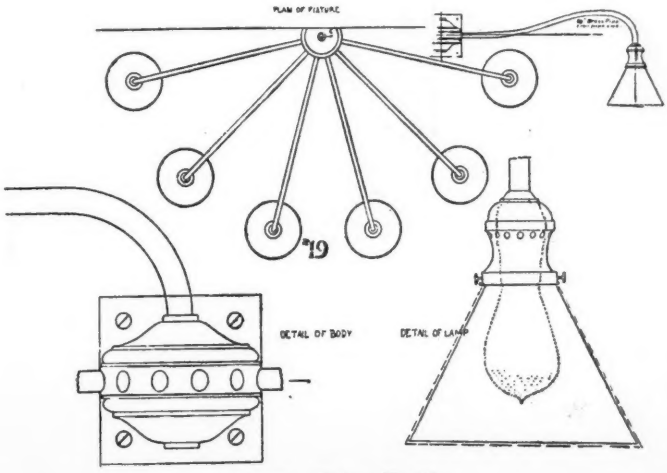


FIG. 25.—Fixture No. 19.

Test 2.—This test was made on the round table in a similar manner, except that the test-plate was viewed through the photometer from the angle at which a reader might view a sheet of paper placed flat on the table. It may be noted that the reader usually places his book near the edge of the table. at which position the effect of regular reflection is practically negligible. Results of measurements in this test follow:

Distance from centre of table to test lamp.	Angle of view with the horiz.	Horizontal illumination.
6 inches	40°	9·6 ft. c.
12 inches	50°	8·9 ft. c.
18 inches	67°	7·2 ft. c.
24 inches	90°	4·8 ft. c.

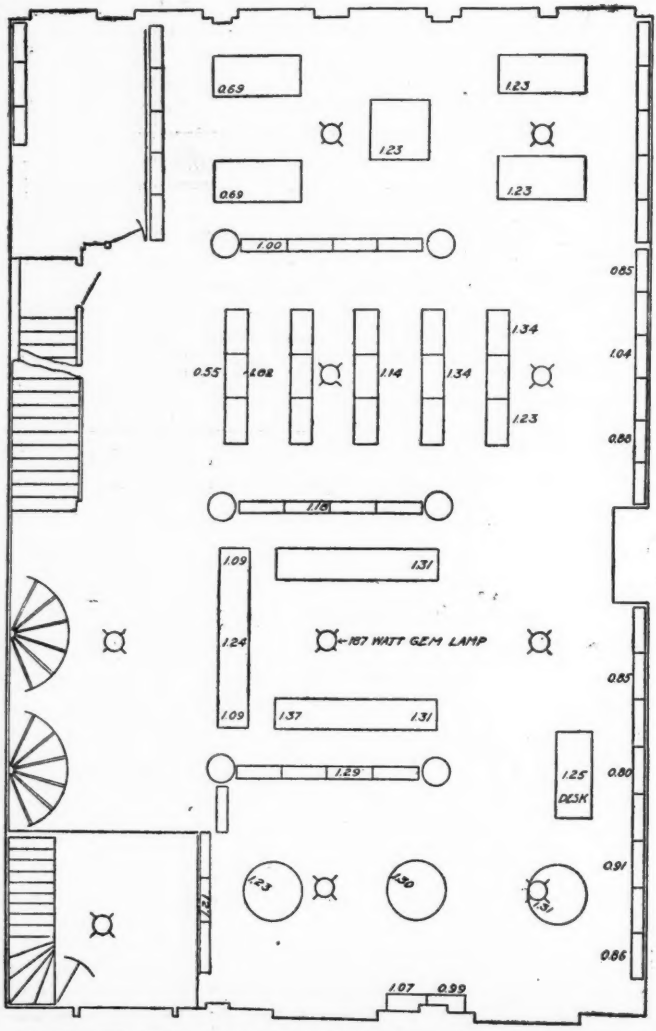


FIG. 26.—First Floor Illumination, all Local Lamps being Extinguished.

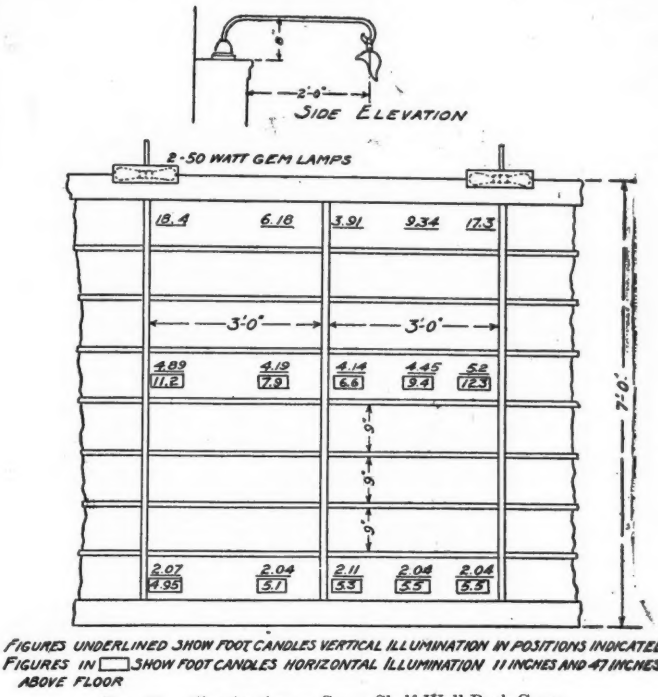


FIG. 27.—Illumination on Seven-Shelf Wall Book-Cases.

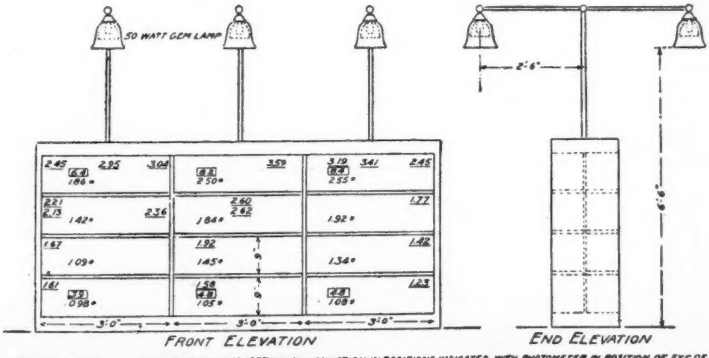


FIG. 28.—Illumination of Free Standing Book Stacks.

The foot-candle values obtained in this test are shown on the plan, inscribed in rectangles.

RECTANGULAR READING-TABLES.

A plan of one of these tables, showing the location of the two lamps which provide local illumination, is shown. Horizontal illumination values determined, as in Test No. 2, of the illumination of the round reading-tables are given upon the diagram, the angle at which the blotting-paper was viewed from the photometer, being in each case approximately 45 degrees above the horizontal.

The foot-candle values are shown on the plans.

ROOF READING-ROOM.

These tests were made with the regular illumination attachment of the photometer. Results are shown in the plan in terms of foot-candles illumination, the figures showing at the same time, by their position upon the diagram, the location of the test-plate during the test.

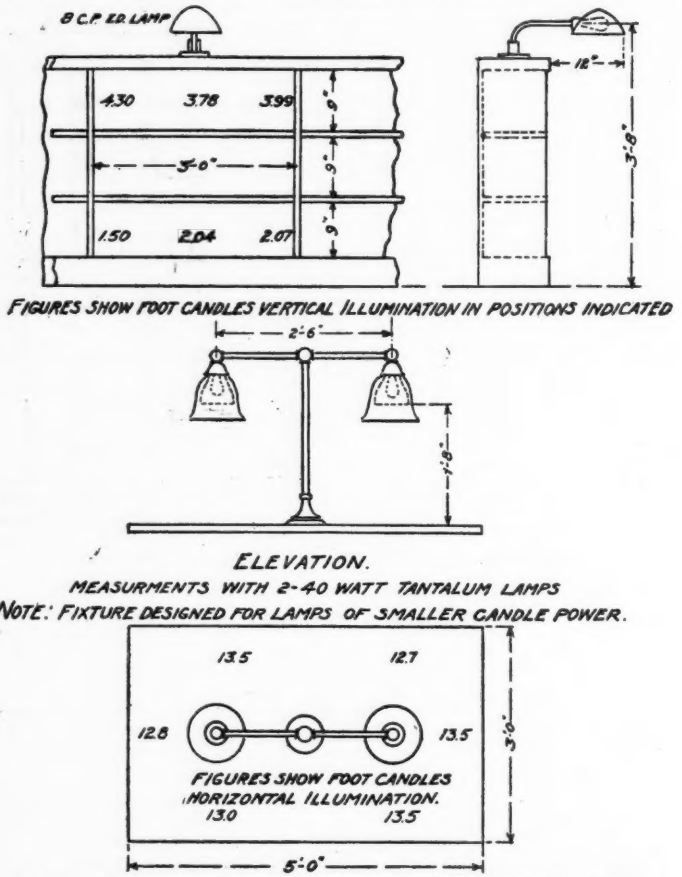


FIG. 29.—Illumination of Low Book Cases and Rectangular Reading Tables.

FEATURES OF THE DESIGN.

1. Freedom from glare; no unshaded lamps. Intrinsic brightness of lighting sources $\frac{1}{10}$ of a candle-power per square inch.

2. General illumination combined with localized illumination.

3. General illumination 1 foot-candle on horizontal working plane.

4. Illumination (horizontal) on reading-tables, average working conditions 5 foot-candles.

5. Illumination (vertical) on bookshelves 1½ to 4 foot-candles.

Illumination (horizontal) on bookshelves 4 to 8 foot-candles.

6. Combination of general and localized lighting designed to secure maximum illumination on the working spaces at minimum cost of operation for the required results.

Distance from center of table to test lamp	Angle of view with the horiz.	Horizontal illumination
6 inches	50°	7.9 ft. c.
12 inches	50°	7.5 ft. c.
18 inches	50°	7.1 ft. c.

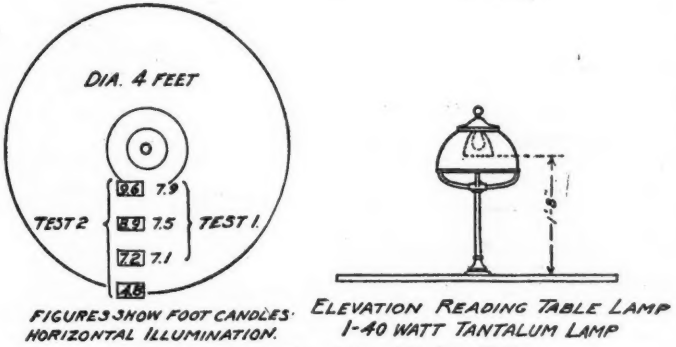


FIG. 30.—Illumination of Round Reading Tables.

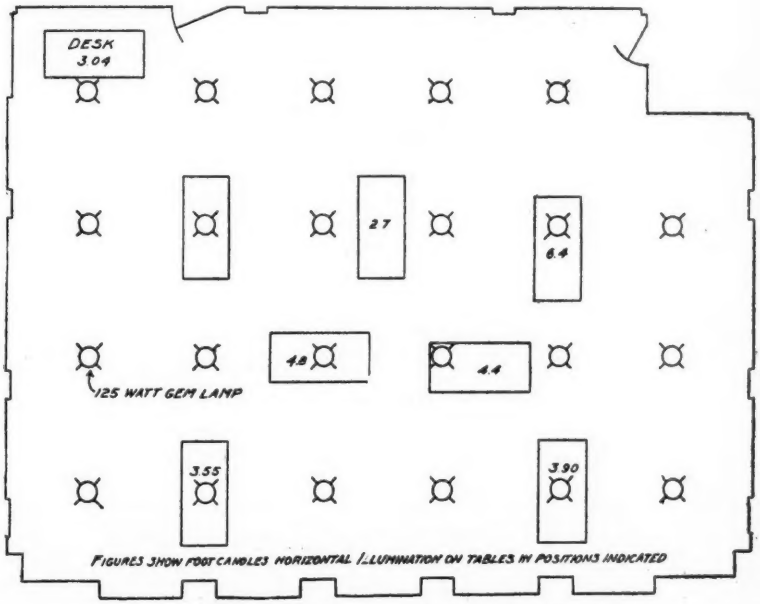


FIG. 31.—Illumination Measurements in Roof Reading Room.

Ceiling pendants for general illumination designed for efficient use of tungsten lamps.

7. Flexibility; design of switching arrangements for economical use of light; lights near windows placed on same circuits so far as possible.

8. Lamps for general illumination hung high, but low enough to avoid sharp contrasts on the ceiling.

9. Lamps for general illumination enclosed in 16 in. crystal glass globes roughed on the outside.

10. Lamps for table-lighting, with prismatic reflectors designed to throw the maximum light sideways instead of downwards; frosted lamps used.

11. Lamps for lighting low bookshelves screened from view by opaque parabolic reflectors. Lamps for lighting wall bookcases, backed by opaque trough reflectors.

12. Lamps for lighting free standing bookcases and reading-tables screened from view by green plated-glass domes.

13. Lamps for lighting exhibition racks screened by reflectors with green celluloid covers.

14. Wall bracket and column bracket-lamps provided with deep enamelled glass diffusing shades of sufficient depth to hide the lamp; frosted tip lamps.

15. Cheerful appearance of room.

DISCUSSION.

Mr. N. W. Gifford asked what was considered the really adequate order of illumination for a reading-table. Was the 5 foot-candles specified in this paper exactly correct? A recent commission on school lighting in Boston had arrived at the figure 2·5 candle-foot, but there seemed much doubt if this was exact.

Mr. P. S. Millar said that the library described in this paper was the only one ever visited by him which he considered well lighted. One could read in comfort and observe the titles of books in the rack without any difficulty. He thought the paper would be exceedingly valuable for future reference.

Mr. C. O. Bond thought there was special opportunity for valuable work which had an important bearing on eyesight in schools and libraries. Unfortunately there were very few instances of really good lighting to be studied. He fully believed in the necessity for constantly presenting educational papers of this description, even though many members of the Society might not yet be educated to the standard of appreciating all the complicated principles involved.

In reply, **Mr. L. B. Marks** said that he took up the work in connexion with this library with the express desire of fulfilling the need to which Mr. Bond had referred, namely the preservation of eyesight.

As a result of six months' study in various public libraries, he came to the conclusion that 2·5 foot-candles was not really enough in cases where foreign languages and characters and any poor type had to be read. In the libraries under his supervision a reader could obtain 10 candles by placing his book in the right position, though he might get only 2·5 candle-feet by arranging his book differently.

One difficulty experienced had been to devise a method of strongly illuminating the book-shelves, which complied with the æsthetic consideration insisted on by the board of architects; eventually they had obtained the necessary 5 candle-feet by local illumination, though the architects preferred general central lighting; another equally great difficulty had been to keep all lights out of the field of view.

With regard to Mr. Gifford's point, he thought that the problem in schoolrooms was essentially different; an illumination might suffice to meet certain fixed needs in a school that would not answer in the case of a public library.

Mr. Marks dealt lastly with a query of Mr. V. R. Lansingh's as to whether the average illumination quoted was determined by calculation of the available flux of light, explaining that whatever system was adopted, the results with diffusing globes compared favourably with those obtained by the aid of open lamps and prismatic reflectors.

The Ives Colorimeter in Illuminating Engineering.

By Dr. Herbert E. Ives.

(Paper read at the Second Annual Convention of the Illuminating Engineering Society, October 5th and 6th.)

(Slightly abbreviated.)

The Ives colorimeter is a practical instrument, designed by Mr. F. E. Ives, for the measurement of all colours in terms of three primary colours.

By means of the colorimeter it is possible to describe a colour accurately in terms of the red, green, and blue components of a standard white light. For instance, in place of the indefinite term "pink," a colour may be designated as

Red, 62; green, 31; blue, 50.

white being

Red, 100; green, 100; blue, 100.

These figures mean that by mixing red, green, and blue light in the proportions given there is produced to the eye the sensation of pink.

Two colours alike to the eye measure alike in the colorimeter. In this it differs from the spectrophotometer, which gives the intensity at every point in the spectrum but only an approximate indication of how the eye will compare the colour in question with another. In the colorimeter, therefore, we have a means hitherto lacking, of comparing numerically the visual effects of such dissimilar sources of light as a gas-flame and a mercury-vacuum arc.

Although designed to measure coloured fabrics by reflected light, the colorimeter may be used to study the colours of various illuminants, and in problems connected with their use.

A brief description of the instrument will be necessary. It consists essentially of an oblong box, at one end of which are placed four slits, one clear, the three others furnished respectively with a red, a green, and a blue colour screen. By means of levers the openings of the three coloured slits may be altered to read by scales from zero to 100. Within the instrument is a wheel of lenses which, when rotated rapidly by a small motor, causes the three colours to pass across the field of vision of an eyepiece, thus mixing them by persistence of vision. The optical arrangements are such that one observes a divided field, one-half consisting of the mixture of three colours, the other the colour to be matched, as viewed through the clear slit. For ordinary use a white surface reflecting the light of the sky serves as standard white, the fabric observed being illuminated by the same light. To make a measurement, the three levers are opened until white is matched, and the scales are adjusted to read 100 for each colour (this method compensates for slight differences in colour vision of different eyes); then any colour matched by moving the three levers can be read off in terms of red, green, and blue used to match white.

For measuring coloured lights this arrangement of apparatus needed modification. Since two different sources were in use—the measured light and a comparison source—the region in front of the instrument was divided by a partition. The light studied was allowed to fall on a flat surface of magnesium oxide placed before the clear slit. On the other side was placed the comparison light, to be described shortly.

The question of a suitable standard to serve for comparison light presented certain difficulties. Average daylight is the logical standard. Daylight, however, varies greatly in character from average, and, moreover, is apt to be so changeable during even a short interval as to render it useless for a series of comparative measurements. It was, therefore, decided to use some reliable constant source, afterwards reducing the figures obtained to average daylight. A practical consideration was that the comparison light should, if possible, be intermediate in character between the extremes of colour to be

measured. The light finally decided on was that of a tungsten lamp operated at 1·13 watts per mean spherical candle.

With the apparatus so arranged the light from any illuminant could be measured and compared with any other. As illustration, the readings of a gas-flame and a Nernst glower were respectively (red, green, blue) 30·7, 38·7, 19 and 44·7, 71·7, 56·3. Choosing such an absolute brightness as will bring the two sources to equality in the red the following ratio is found :—

	Red.	*Green.*	*Blue.*
Gas ÷ Nernst	1	·78	·51

Table I. gives the results of a set of measurements on twenty-one different sources of light, expressed in terms of average daylight, the latter obtained in the way to be described below.

It was at first hoped to express the results in terms of the average daylight obtained by Prof. E. L. Nichols from spectrophotometer readings, and reported in the May number of the *Transactions of the Illuminating Engineering Society ;* but this idea was abandoned, mainly because Prof. Nichols's average daylight, as nearly as could be determined, is much yellower than any daylight observed in Washington during the period of the work, and is, indeed, considerably more yellow than sunlight.

It was, therefore, thought best (as most convenient) to use as the standard the average daylight during the time the work was carried on.

The " average daylight " of the table is obtained from fifteen sets of observations made during an interval of three weeks. They fall naturally into three groups : blue sky, partly cloudy or foggy sky, and entirely overcast sky. The averages of these groups, in terms of the comparison source, were :—

	Red.	Green.	Blue.
Blue sky	7·9	25·8	100
Cloudy	9·3	27·8	100
Overcast	11·2	30·4	100
Mean	9·5	28	·100

To facilitate comparison the values for red were made equal for all of the lights.

In the table the sources are arranged roughly in the order of their approximation to daylight ; sunlight and the carbon arc are near the head of the list, the Hefner at the foot. The figures for the Moore tube were obtained indirectly from observations made in the New York Post Office by Mr. F. E. Ives, with a glow-lamp as a comparison source. The helium tube is included, because it has been suggested as a primary standard. The tungsten, Nernst, tantalum, graphitized filament and carbon glow-lamps were run at their normal specific consumption as determined by measurement of each lamp for mean spherical candle-power, current, and voltage. This was found of the utmost importance, for two reasons : first, because the colour depends on the specific consumption ; secondly, because in all but one case the manufacturers' rated voltages were far enough wrong to place the lamps in a different order from the correct one. At the conclusion of the measurement the five lights were compared directly with each other for colour, on a photometer bench, and their relative positions in the list were found to be correct.

Following the colorimeter measurements of the sources themselves, a brief study was made of colour changes under artificial light. It is known that the colour of a surface illuminated by most artificial sources differs greatly from its colour under daylight. At the same time the change in all colours is approximately the same, so that they keep their relative places fairly closely. This fact may be expressed differently by saying that the change in colour of a white surface under artificial light is a fair guide to the change in colour of a coloured surface. Exceptions to this will occur to every one ; nevertheless, unless the source of light is quite selective, or the reflective power of the surface very selective, the rule holds good.

It was thought of interest to measure with the colorimeter the change of colour of coloured surfaces, under different lights, and then to see how closely these changes followed the altered readings for a white surface

under the same conditions. The results should show whether the colorimeter readings for a white surface under varied illumination give a good indication of the readings for a coloured surface whose readings are known for daylight. For this purpose a number of coloured cloths and papers were selected whose dominant hues ranged throughout the spectrum; of these, several were chosen because they showed great changes in appearance under different lights. Mounted on a disc together with a white surface they were read under daylight, the light from a tungsten lamp, a glow-lamp, a Welsbach, and a Cooper-Hewitt mercury arc.

As was to be expected, the direct readings showed great differences in colour according to the kind of illumination. A lavender silk, for instance, gave the results :—

	Red.	Green.	Blue.
In Daylight ..	3	7·2	31·8
Under Welsbach...	10·2	15·4	17·6
Under Glow Lamp	20·2	20·9	16·2
Under Mercury Arc	6·5	5·5	44·

Making the readings equal in the red to fit them better for comparison, they became :—

	Red.	Green.	Blue.
Daylight... ...	100	240	1060
Welsbach ...	100	151	173
Glow Lamp ...	100	107	80
Mercury Arc ...	100	845	676

A large portion of the enormous difference is, of course, due to the change in colour of the light; in order to take this into account the following procedure was adopted: all measurements were reduced to the basis of white=100, 100, 100; that is, all the daylight readings were multiplied as before by the factors to make the daylight readings on white 100, 100, 100, and similarly the artificial light readings were multiplied respectively by the factors necessary to make white as given by them read 100, 100, 100. This being done, it follows that if coloured objects under different light change their readings in the same proportion as does white, their readings so reduced should be the same in all cases.

TABLE I.—Colorimeter Readings on various Sources.

Source.	Red.	Green.	Blue.
Average Daylight	100	100	100
Blue Sky, mean of five sets	100	106	120
Overcast Sky, mean of four sets	100	92	85
Sunlight, 2 P.M., August 19th	100	95	68
Sunlight, afternoon observations, 2 to 5 P.M.	100	91	56
Nichols' Average Daylight (acetylene flame and A. O. Co. blue glasses 5 and 1)	100	69	42
Carbon Arc, direct current	100	64	39
Mercury Vacuum Arc (Cooper Hewitt)	100	130	190
Moore Carbon Dioxide Tube	100	120	520
Welsbach Mantle, $1\frac{1}{2}$ per cent. cerium...	100	81	28
Welsbach Mantle, $2\frac{3}{4}$ per cent. cerium	100	69	14·5
(Mantle preferred by Welsbach Co. for residential illumination.)			
Welsbach Mantle, $3\frac{1}{4}$ per cent. cerium,..	100	63	12 3
Tungsten Lamp, 1·57 watts per mean spherical c. p.			
Tungsten Lamp, 1·25 watts per mean horizontal c- p.	100	55	12·1
Nernst Glower, bare, 118 volts, ·4 ampere	100	51·5	11·3
Acetylene Flame	100	50	10·4
Tantalum Lamp, 2·5 watts per mean spherical c. p.			
Tantalum Lamp, 2·0 watts per mean horizontal c. p.	100	49	8·3
Graphitized Filament, 3·1 watts per mean sperical c. p.			
Graphitized Filament, 2·5 watts per mean horizontal c. p.	100	48	8·3
Glow Lamp, 3·9 watts per mean spherical c. p....			
Glow Lamp, 3·1 watts per mean horizontal c. p.	100	45	7·4
Flaming Arc	100	36·5	9
Helium Tube	100	37·0	9
Gas Flame, open fish-tail burner	100	40	5·8
Moore Nitrogen Tube	100	28	6·6
Hefner	100	35	3·8

In the following table the results are given for seven miscellaneous colours under five sources.

TABLE II.

Change of Colorimeter Readings with various Illuminants.

Figures are reduced to the basis of white reading 100, 100, 100 for each light.

	Red.			Blue.			Buff.			Pink.			Pine Wood.			Lavender.			Dull Green.		
Daylight ..	37·0	5·9	7·6	11·0	15·8	35·1	82·9	65·7	48·1	77·3	48·0	61·9	45·5	30·3	16·8	36·6	32·6	44·8	35·7	33·5	26·2
Tungsten ..	41·9	6·7	6·4	8·6	12·0	36·7	83·	60·2	38·5	88·3	52·1	73·8	49·8	32·6	21·0	47·6	37·7	68·8	30·5	28·7	24·2
Welsbach ..	40·5	6·8	0	11·0	13·9	41·1	82·5	62·8	44·0	82·8	51·4	65·7	44·6	29·2	15·0	34·2	28·2	51·6	33·5	31·7	26·1
Glow	44·4	7·7	0	9·7	12·7	43·6	83·3	62·8	42·2	92·7	61·4	74·0	50·5	35·0	17·2	49·0	41·4	79·4	30·3	31·1	29·9
Mercury Arc	17·4	4·5	8·3	21·5	11·0	33·9	87·4	73·6	42·9	68·2	49·4	77·0	36·5	32·3	12·4	38·9	27·7	48·9	35·9	31·8	22·1

It will be observed that, in place of the extreme differences obtained in the direct readings, the colours readings are not greatly different under different lights. In other words, the colorimeter readings roughly follow the change of illumination, as does the eye.

From these figures the best light of the five for matching colours is that of the Welsbach, while that of the Cooper-Hewitt, an extremely selective source, exhibits wide deviations. That the latter should be the case is to be expected. The radiation from the mercury arc consists of a few bright lines in the spectrum, and the effect on a white surface may be indistinguishable to the eye from the illumination obtained from a source with a continuous spectrum. A coloured surface, having its predominant colour in a different region of the spectrum from the mercury arc will not reflect its light but will reflect the light of the similarly appearing source with the continuous spectrum. It will appear dark under one source, bright under the other. Hence in the case of a selective source the colour of a white surface is no guide, either for the eye or for the colorimeter, to the effect on a coloured surface.

The result of the work thus far done with the colorimeter, as applied to illuminating engineering, may be summarized here. By means of the colorimeter the colours of all types of sources may be described in terms of a given standard such as daylight. The figures expressing the colour of a light are a fair indication of the change in the colour of objects illuminated by it.

The question may be raised as to just what the colorimeter readings mean, for instance, in terms of the spectrophotometer, or of the primary colour sensations. Strictly speaking, all that they give are the mixing proportions of three special colour screens. Measured on the spectrophotometer these screens are found to possess transmissions which are fairly narrow and well separated, whose maxima (taking into account the sensibility of the eye) fall at red$=0{\cdot}635\mu$, green$=0{\cdot}535\mu$, blue $=0{\cdot}455\mu$, or very closely at the wave lengths Maxwell chose for his primaries. As these colour screens are probably the best available for the purpose, and as the instrument is expected to come into general use for the measurement of colour, the colorimeter readings will constitute of themselves a sufficiently definite standard for many purposes.

It is desirable, however, to be able to reduce the readings to some fundamental standard. With this object in view the writer is now engaged in finding the values of the screens in terms of the three primary colour sensations. When this has been completed it will be possible to reduce colorimeter readings directly to colour sensations, or, given the spectrophotometer readings of a colour, to obtain from colour sensation curves the colorimeter readings.

The Ives Colorimeter in Illuminating Engineering.

DISCUSSION.

Dr. Bell expressed his sense of the value of the paper; there seemed a need for a simple form of instrument, such as that of Mr. Ives, designed for the comparison of colour-values.

Mr. D. McFarlan Moore agreed that the instrument was a useful one, but took exception to the tables of colour-values presented by Mr. Ives. He contended that the carbon dioxide tube ought to stand as the illuminant most closely resembling daylight, and was superior to the arc-lamp in this respect. This result had been confirmed by many workers on vapour-tubes, including Prof. Utzinger, who plotted a spectrum-curve of the carbon dioxide tube ,and found that it resembled average daylight very closely indeed, being, however, slightly stronger in the blue. Prof. Utzinger also preferred in such comparative work to utilize not three but *four* colours, namely red, yellow, green, and blue.

Mr. Moore also criticized the method employed by Mr. Ives in his tests of the Moore tube at the New York Post Office. Continuing, Mr. Moore declared that the carbon dioxide tube was unique for the purpose of matching silks, &c., and ought, in his opinion, to be selected as a standard spectrum.

Dr. E. P. Hyde made an explanation of the exact conditions under which the tests at the New York Post Office, referred to by Mr. Moore were carried out. He thought the Ives colorimeter served excellently to indicate the appearance of a white surface illuminated by lights of different colours, and might also be applied to coloured surfaces provided the sources studied did not radiate too selectively.

Mr. Ives said that he considered the Moore carbon dioxide tube the most satisfactory artificial illuminant for the comparison of colours, but thought that it resembled the blue sky rather than diffused daylight. It was however, very much bluer than the arclight.

Dr. Bell pointed out that probably no one illuminant could be considered the best for matching the colours of all classes of goods; the goods in a tailor's shop, and at the ribbon counter demanded different kinds of light.

Mr. E. L. Elliott expressed his appreciation of Mr. Ives's paper, but thought that it was impossible for the light from the carbon dioxide tube to be bluer than that of the mercury arc, as Mr. Ives's results would suggest.

Dr. E. P. Hyde stated that actual observation of the two sources confirmed this result. Those present were all of opinion that the mercury tube appeared the greener of the two, but that the carbon dioxide tube was certainly the bluer in appearance.

Mr. J. B. Klumpp asked whether the Ives colorimeter could be applied to the study of colour blindness.

Mr. H. E. Ives said that the colorimeter was an exceptionally sensitive instrument for this purpose. He also emphasized the fact that it was impossible to compare the effects of differently coloured lights by memory. If we entered a room lighted by one illuminant and, after an interval of an hour or so, a second room illuminated in an entirely different manner, we might believe the two to be the same; but, regarded side by side, the difference would appear startling.

He thought that Mr. Moore must be mistaken in supposing that four colours instead of three could be used for mixture. An observer using a spectrophotometer might examine four positions in the spectrum; but the Ives colorimeter actually mixed, in suitable proportion, the three primary colours.

Mr. Ives confirmed the statement of previous speakers that the Moore tube is bluer than the mercury arc. He also stated that in his experiments he had followed Dr. Nichols's attempt to express results, not in terms of light from the clear or diffused sky, but in *average daylight*.

Street Lighting with Gas in Europe.

By E. W. Wrightington.

(Abstract of Paper read at the Second Annual Convention of the Illuminating Engineering Society, Oct. 5-6th, 1908.)

Gas is used in Continental European cities in many forms. Low pressure upright lamps, such as are familiar in America are mainly used for side streets. High pressure gas is coming into extended use for main thoroughfares; the inverted lamp, however, is now replacing the upright type.

High pressure upright lamps are mainly employed where large units for special lighting are wanted; low pressure lamps are placed nearer together than in the United States, giving rise to a satisfactory distribution of light.

The efficiency of the upright lamp is exceeded by that of the newer inverted lamps. This can be explained: *firstly* because the proportion of light below the horizontal, where it is needed in the streets, is greater in the case of the inverted burner, and *secondly* because the use of inverted burners facilitates the use of suitable reflectors.

The number of mantles used is less than in the case of the upright lamps. The inverted lamp lends itself specially well to artistic treatment; an effective arrangement is secured by double-arm posts, staggered on each side of the street at intervals of 100 feet or so.

The author considers the most striking feature of the street lighting in Europe to be the use of high pressure inverted gas lamps, in very large units, up to 3600 mean lower hemispherical candle-power. The posts are placed near together, and the streets are almost as bright as if lighted by daylight. Yet the light is not glaring, even when the lamps are hung rather low, but beautifully diffused, the effect being very soft and pleasing.

From one to three mantles of large size are used for each lighting unit. These mantles are attached to the lamp non-collodionized. A by-pass is used, and the pressure, which amounts to about 60 inches, opens the valve, and the lamp is ignited. The mantles shrink to the proper size, and form naturally on the burner. At midnight one or more of the burners of each lamp may be extinguished

The author remarks on one important difference between the conditions in Europe and in the States. Wherever, in America, there is a traffic at night which would require such a great quantity of light as exists over here, very little outside illumination is needed. The streets in America are lighted by private citizens by means of window lamps and signs. For example, along Broadway, in New York, the so-called street lamps are hardly necessary, and the light which they give is almost entirely overshadowed by the private lighting around them. Wherever there is traffic, there are window lamps and signs; or putting it the other way, the signs and window lamps attract the traffic.

In continental cities, on the other hand, it is the rarest thing to find any windows lighted after dusk. The shutters are pulled down tight, and the lighting of the streets is dependent entirely upon the street lamps. Yet at the same time, a very great amount of light is needed, as the traffic both on foot and on wheels is very heavy. For this reason where lamps of 3600 candle-power, 100 feet apart, may be necessary in Europe, it is probable that such a very large amount of light would not be needed except for special lighting in the United States.

It is reasonable, however, to expect that small units, both under high pressure and low pressure, adjusted to suit local conditions, may be used in the United States. Inverted lamps giving on low pressure an output of from 30 to 40 candle-power per cubic foot of gas consumed per hour, and on high pressure from 50 to 60 candle-power, might well be installed at intervals, and should give a satisfactory illumination at a reasonable cost.

Modern Gas Lighting Conveniences.

By T. J. Litle, Jun.

(Abstract of Paper read at the Second Annual Convention of the Illuminating Engineering Society, Philadelphia, Oct. 5-6th, 1908.)

Modern incandescent gas lamps have reached such a high state of perfection and efficiency that it is well to direct attention to the various inventions and improvements that have been made for their ignition and control. These devices have naturally greatly popularized the gas system of lighting in the last few years, as it is generally conceded that when the proper methods are employed, illumination by gas is beyond criticism due to the remarkably perfect combustion in the modern burner, resulting in a greatly increased lighting efficiency, thus requiring fewer units than heretofore; moreover their more satisfactory colour value must not be overlooked.

The modern ignition of gas burners may be accomplished in various ways, but it may be divided broadly into two general classes; namely, electric and pilot flame.

The electric spark ignition may again be divided into two classes, the jump spark (high-tension) ignition, and the interrupted-circuit low-tension (make and-break) ignition. They may be further divided into other classes, differing somewhat in mechanical detail, but the following remarks will be confined to those above stated.

JUMP SPARK ELECTRIC IGNITERS.

The jump-spark igniting system is used where a large number of burners are to be ignited simultaneously, such as in shop windows, store interiors, churches, public halls, factories, &c. In this case use is made of an induction coil of such a size as to produce a spark of sufficiently high potential to jump the distance equal to the sum of the air gaps in the circuit. On account of its high potential, great care must be exercised to prevent leakage in the secondary circuit. To obtain good results not less than six standard dry cells should be used in the primary circuit. The push buttons may be located at any convenient points. For greater convenience, however, the whole electric outfit may be placed in a cabinet that is completely wired, and all that is necessary on installation is to run the secondary leads from the cabinet to the burners. Such a cabinet is illustrated in Fig. 1. The hundreds of inverted lamps which are used there are centrally controlled by grouping the gas pipe circuits, as well as the secondary circuit of the jump-spark ignition system.

In addition it may be mentioned that with this system any number of lamps may be ignited by a division of the secondary circuit; that is, if the rating

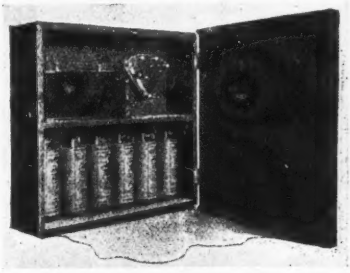


Fig. 1.–Cabinet containing Jump Spark Lighting Equipment.

of the coil is 20 burners, all that is necessary is to divide the lamps into groups of 20. The wire used in the secondary circuit may be very fine; phosphor bronze of No. 30 gauge, on account of its great tensile strength, has been very successfully used. This wire may be suspended from burner to burner, being practically invisible. In this case use is made of the secondary distribution switch shown in the upper right hand portion of the cabinet. The gas is usually controlled mechanically, either by providing a gas cock adjacent to the spark cabinet, or if the cabinet happens to be at an inaccessible point,

the cock may be operated from a distance by a mechanical pull device. The latter system has been used quite extensively where the existing gas piping was not conveniently arranged for the placing of the shut-off cock.

AUTOMATIC ELECTRIC IGNITER.

The automatic electric igniter for an upright burner is shown in Fig. 2. With this attachment it is possible to place push buttons at any distance from the burner for igniting and extinguishing. The small magnets in the cylindrical shell open and close the gas cock, and the vibrating make-and-break produces the igniting spark. The ignition of the burner in this case is accomplished indirectly by a climbing flash-pilot, which remains flashing only so long as the ignition button is pressed.

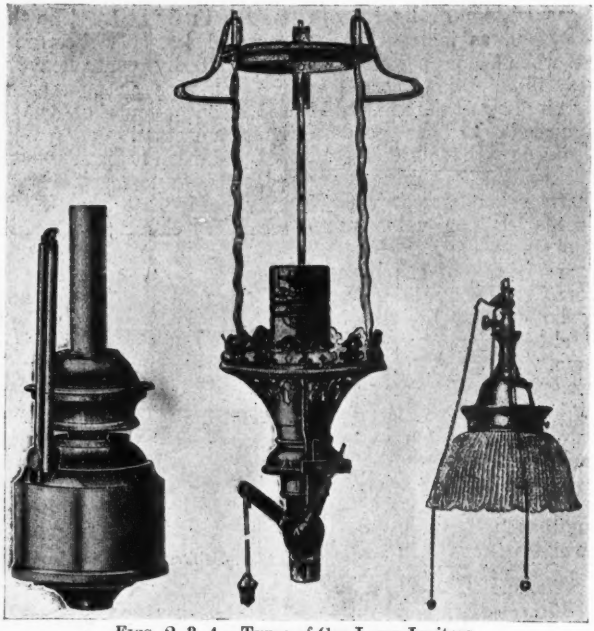
PENDANT ELECTRIC IGNITERS.

The pendant, or pull type of igniter, is operated at the burner; it consists of simply a gas cock to which is attached a pulling lever and an arm carrying a wiping sparker, which ignites a flashing pilot. In this case pulling down on the lever turns on and ignites the gas, while pushing up the lever closes the cock. See Fig. 3.

The above two igniters are designed principally for residence use.

PILOT IGNITION.

The pilot system of igniting gas burners on account of its simplicity, is probably the most widely used of all. See Fig. 4. In this case a very small jet of gas is maintained at the end of a small pilot tube adjacent to the mantle. The gas cock is operated by means of chains. This system is generally adapted for residence lighting. The pilot flame is so situated as to be well protected from ordinary drafts, and the consumption of gas is so slight ($\frac{1}{12}$ cubic feet per hour) as to be practically negligible. This system has been utilized very successfully on gas "arc" lamps, a sectional view of one of which is shown in Fig. 5.



FIGS. 2, 3, 4.—Types of Gas Lamp Igniters.

MULTIPLE PILOT IGNITION.

Under this heading may be men-

tioned the application of pilot ignition for a large number of burners, as shown in Fig. 6. In this system the pilots for igniting the burners are supplide with gas from an independent feed line, and in igniting it is necessary merely to turn the gas on to the main supply pipe feeding the burners; when the gas reaches the mantles it is ignited by the pilots.

AUTOMATIC CLOCK CUT OFF.

In conjunction with both of the above systems, the automatic clock cut off is adapted to show-window and other forms of lighting where it is desired to extinguish the light automatically at any predetermined time. In this case the main shut-off cock supplying gas to the burners is provided with a weighted lever which is held in its open position by means of a chain attached to a catch in the rear of the clock, and when the clock train starts in motion this chain is removed from its supporting hook and the gas cock closes. This operation may be reversed so that the lamps may be ignited at any predetermined time.

PILOT IGNITION FOR CLUSTERS.

The latest application of the multiple pilot system of ignition is shown in Fig. 7. In this case several inverted burners are supplied with gas for pilots from a point immediately above the shut-off cock, which is concealed within the shell of the fixture, as shown in Fig. 8. The gas is ignited by pulling the white ring, which depends from the fixture. This arrangement is decidedly convenient for the shop-keeper.

PNEUMATIC PILOT IGNITION OF CLUSTERS.

In this case the lamps are ignited in very much the same manner as in the case above mentioned, but the gas is controlled by a pneumatic cock, as shown in Fig. 9. A small copper tube runs from the chandelier to the operat-

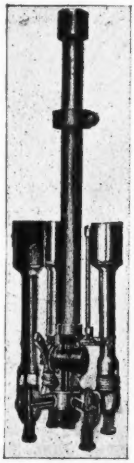


FIG. 5.—Section of Gas "Arc" Lamps.

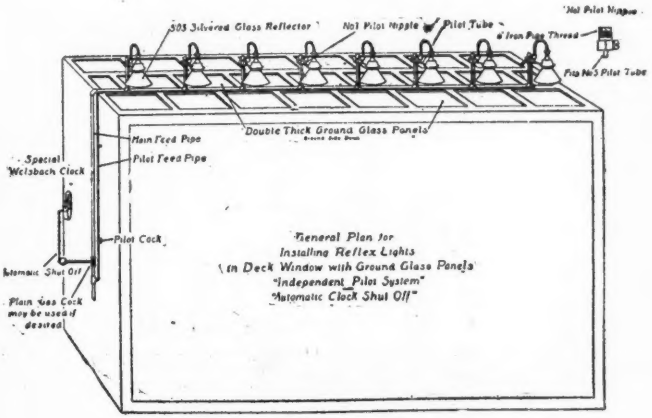


FIG. 6.—Independent Pilot System of Ignition.

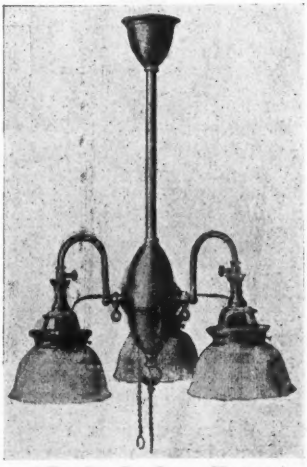
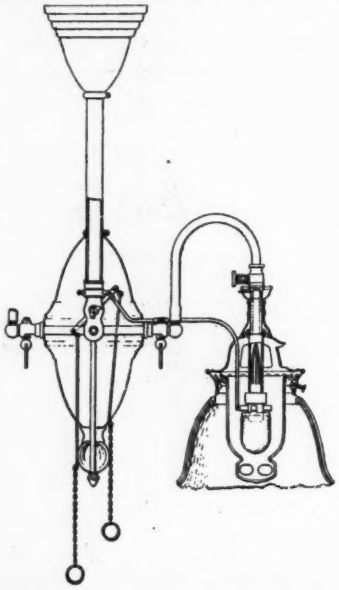
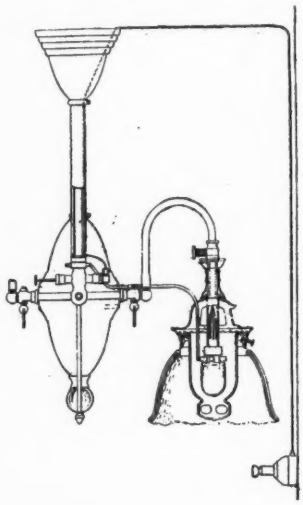


FIG. 7.—Gas Lamp Cluster.

ing push button, which is in reality a small plunger pump. On pushing the plunger inwardly, air compressed along





FIGS. 8 and 9.—Gas Lamp Ignition Schemes.

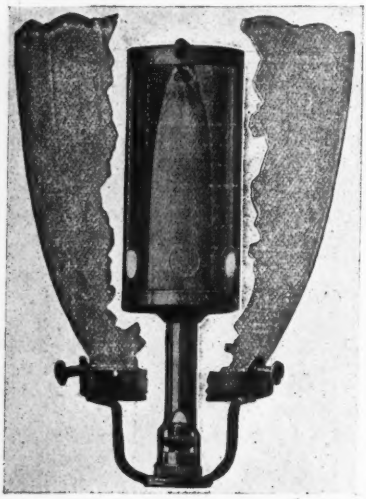


FIG. 10.—Miniature Gas Lamp.

the entire line advances the piston valve, thus opening it; in order to extinguish, the plunger is pulled outwardly, thereby creating a partial vacuum and the piston valve is moved into the closed position. In addition to being able to ignite and extinguish the gas from a distance, it is also possible to do so at the fixture, as the plunger is equipped with an extension terminated by a push button which projects through the shell, and this may be operated by hand. The pneumatic lighter is also applied very successfully to single burners—both upright and inverted.

MINIATURE GAS UNIT.

Under the heading of convenience may be mentioned the mantle arranged within a small mica chimney. It is provided in this form as a unit, which enables the consumer at one application to renew the mantle and obtain a new mica chimney. This result is rendered possible on account of the small size and consequent cheapness, just as is the case with the carbon filament lamp. These units consume less than 2 cubic feet of gas her hour—to be exact, 1·69 cubic feet, under 2 inches of gas pressure. The widespread application of this small unit can be readily appre-

ciated when it is shown that the output is actually 51 candle-power with the above named consumption. It is admirably adapted to residence lighting where small units are desirable.

It may be used in place of the lava-tip burner without affecting the symmetry of the fixture. Standard electric glassware may also be used with it, as shown in Fig. 10; on this account is well adapted for combination gas and electric fixtures. The chain pull by-pass, with side pilot, may be applied to this unit.

MISCELLANEOUS.

So far the remarks have been confined to the various igniting schemes for incandescent gas burners; a great many ingenious devices have also been employed in connexion with gas "arc" lamps for outdoor use, such as in railroad stations and railway yards. In this case the "arc" lamp is attached to a mast-arm device, the operation of trimming the lamps being as shown in the cut. Another convenient application employed with the outdoor lamp is illustrated in Fig. 11, where the globe has been lowered on to the hook below the lamp and the operation of replacing a mantle is shown. The remaining mantles are protected from the wind by the cylindrical shell which automatically follows the globe on its removal.

Flexible metallic gas tubing has been very generally adapted for use in connexion with inverted burners. This tubing is made by spirally winding a corrugated metallic ribbon, with asbestos cord intervening, to make the joint gas-tight the corrugations serving not only to retain the asbestos cord but at the same time locking together the convolutions. In machine shop practice these tubes are suspended either from



FIG. 11.—Gas "Arc" Lamp with Globe.

an overhead stationary gas pipe or from an inverted swing gas bracket. The latter makes it possible to shift the lamp over a considerable area.

DISCUSSION.

Dr. L. Bell, the President, opened the discussion, remarking incidentally that, according to his experience, most electric methods of ignition for domestic purposes were very apt to get out of order.

Dr. Clayton H. Sharp said that the problem of electrical ignition resolved itself largely into a question of insulation, which, in the case of the older systems, was often inadequate. Dr. Sharp also referred to the possibility of danger arising from the extinguishing of the pilot-flames by draughts of airs, &c., especially when water-gas is used.

Mr. F. N. Morton asked whether the self-lighting mantle was still being investigated, and whether the pyrophoric alloy-lighters were likely to be successfully developed.

Mr. V. R. Lansingh asked if pilot-lights on a multiple burner could be arranged so that only one single light

of a group could be burnt, instead of a cluster.

Mr. H. Calvert inquired how many burners could be operated from a pneumatic system at once, and at how great a distance.

Mr. W. Forstall mentioned a case in his experience in which a pilot-flame was accidentally extinguished and the gas escaped for 48 hours; yet on his return there was only a very faint trace of the odour of gas.

Mr. F. Beck estimated the distance at which a single light could be turned on and off by the ordinary pneumatic arrangement at 20 yards for a single light. This distance was somewhat reduced for a series of lights. Among advantages of the system he claimed simplicity and greater safety. Electric lighters required to be installed and supervised by an expert. Pneumatic arrangements could also be contrived to turn on a series of lights on a chandalier either all at once or one at a time. In cases in which lights were to be ignited simultaneously electric ignition had the advantage that it could be operated at a greater distance.

Mr. C. W. Hare wanted to hear further experience of the pneumatic system in practical working.

Mr. L. D. Gibbs thought that troubles with electrical ignition very often arose from a system of wiring being adopted that was utterly incapable of doing what was expected. For instance, he knew of houses in which ordinary bell-wire had been employed.

Mr. N. W. Gifford knew of many cases in which electric ignition was used without complaint.

Dr. L. Bell, in closing the discussion, said he could confirm the suggestion that the average electric igniting failed through faulty insulation, a simple cotton-covered wire being often considered sufficient. Dr. Bell also inquired as to the practical working of the iron-cerium light recently developed by Dr. v. Welsbach.

In reply, **Mr. T. J. Litle** agreed that in the case of the "jump-spark" system, where a P.D. of several thousand volts was developed, a very perfect system of insulation was required. In cheap systems poor insulation was sometimes the cause of failure, and in many of the older installations the wires were simply embedded in plaster, which eventually caused the insulating covering to rot.

Many of the early burners were also badly arranged. In cases in which a "wipe-contact" was used the contacts sometimes stuck, thus permanently short-circuiting the battery. Nowadays this possibility was eliminated. Naturally, however, the batteries wanted occasional and proper attention.

Mr. Litle thought that the results of an escape of gas owing to the pilot-flame being accidentally extinguished were insignificant, because the gas used was so small, and the natural ventilation of the room changed its contents quicker than the gas was evolved. Explosion from this source was impossible, for the correct proportions to cause this result could never be attained in an ordinary well-ventilated room.

Unfortunately the self-lighting mantle had not yet been developed to a commercial stage. At present pyrophoric mantles might answer excellently for a few months, but apparently this quality was gradually destroyed by the action of heat.

The pyrophoric alloy of iron and cerium was as yet only in the experimental stage. In appearance the alloy briquettes resembled cast iron, but yielded a stream of sparks when scratched with a file. It was hoped that this would prove a successful type of gas-lighter, and would be used both for kindling gas-lights and in the cylinders of gas engines.

With regard to Mr. Lansingh's inquiry, pilots were all regulated separately: by the removal of the little pilot-adjusting screws all but a single burner could be put out of action.

Mr. Litle also referred to an improved form of pump with a cork piston, reinforced with a metallic washer on either side, for use with a pneumatic arrangement; the life of such a piston is longer than of the older leather-disc types.

The Integrating Sphere in Industrial Photometry.

By Clayton H. Sharp and Preston S. Millar.

(Abstract of Paper read at the Second Annual Convention of the Illuminating Engineering Society, Philadelphia, Oct. 5–6th, 1908.)

The authors commence their paper by making a brief reference to the various types of integrating photometrical devices that have been devised, including the lumen-meters of Blondel and Kenelly, and the integrating photometer of Matthews.

Their object in the present paper is to discuss the merits of the Ulbricht globe, and they preface an account of their experiments by a general treatment of the theory of the instrument. As readers of *The Illuminating Engineer* have had an opportunity of becoming acquainted with this in the recent contributions of Dr. L. Bloch and others, (*Illuminating Engineer*, April and July, 1908), we will proceed at once to deal with the latter section of this paper.

During the past two years experiments have been made with integrating spheres at the Electrical Testing Laboratories in New York with uniformly favourable results. Four different sizes of spheres have been used. Three, respectively 11 in., 18 in., and 30 in. in diameter, have been used with incandescent lamps (Figs. 1 and 2). One, approximately 80 in. in diameter (see Fig 1), has been provided for tests of arc lamps and large incandescent lamps, gas lamps, &c.

Description of Sphere.

The 18 in. sphere, illustrated in Fig. 1, is typical of the smaller spheres It is provided with a hinged door, A, through which the test-lamp is inserted. B is a shaft on the lower end of which a screw thread socket is fixed. As shown in the cut, this shaft and socket may be turned by pulling a cord which passes over the shaft pulley. To mount an incandescent lamp in the sphere, it is necessary merely to thrust the lamp base into the socket and rotate the latter by means of the cord until the lamp is screwed home. A reversal of this procedure unscrews the lamp. C is a small window fitted with translucent glass having the property of substantially uniform transmission of light of all wave-lengths throughout the visible spectrum. The brightness of this translucent glass, as viewed through the photometer from D is proportional to the total light flux of the source in the sphere.

Between the light source and the translucent glass window is placed a screen of the same kind of translucent glass with which the window is equipped This screen is reduced to the smallest possible dimensions, the only requirement being that all parts of the light-source shall be obscured from the translucent glass window.

The interior of the sphere is provided with a white diffusing coating, in the selection of which the following necessary features have been considered :—

Nearest approach to perfect diffusion.

Absence of selective absorption.

Permanency of surface.

All exposed interior parts of the sphere, such as lamp mountings, &c., are covered with the same coating.

The large sphere illustrated in Fig. 3 is composed of hemispheres separated along a vertical plane, and mounted upon flanged wheels running on rails, so that the hemispheres may be separated readily. The door A is provided in order to give access to a standard lamp socket F. The translucent glass window C is shown in Fig. 3, while the photometer attached to it is shown in Fig. 2. The light from the standard lamp F is obstructed in the direction of the window C by a translucent screen. The light-source to be tested may be located in any part of the sphere. The apparatus in this case is designed particularly for use with arc-lamps which are inserted through an aperture in the top of the sphere, or by separating

the hemispheres. Other illuminants may, if desired, be inserted through an aperture in the bottom of the sphere (not shown in illustration). In all cases, however, the translucent screen H must be so located as to screen the light source under test from the window C. In other respects, the large sphere is constructed along lines similar to those of the small spheres.

Some Difficulties encountered in the Use of the Sphere.

A light-source having a large surface absorbs a certain percentage of the total light flux in a sphere. Thus the frosting on a lamp bulb in a small sphere, and an opal arc-lamp globe in a large sphere, may absorb enough light to reduce the illumination upon the translucent glass window materially. To obviate this difficulty, the larger spheres are standardized by an incandescent electric lamp standard, after the lamp to be tested has been placed in the position which it will occupy duriog the test. By this means the absorption by the test lamp is compensated for.

In the smaller sphere, the best means of overcoming the difficulty of light absorption is to use standard lamps of the same character as those to be tested, relying upon the substitution method implicitly.

Examples of the errors encountered in this connexion are as follows :—

Absorption of light by 12 in. opal globe in 80 in. sphere ..	3%
Absorption of light by enclosed arc-lamp in 80 in. sphere ..	5%
Absorption of light by discoloured bulb, 16 c.-p. lamp in 11 in. sphere	1%

As has been pointed out above, the screen between the lamp and the translucent window is the chief source of error in the sphere ; hence, it is to this feature of construction and arrangement that the experimental study of the authors has been chiefly directed. As a convenient means of testing the screening arrangement, use has been made of an incandescent lamp with very dis-symetrical light distribution produced by painting one side of the bulb black.

Tests of small spheres with a lamp of distorted light distribution, as described above, have shown that when an opaque screen is used and the un-

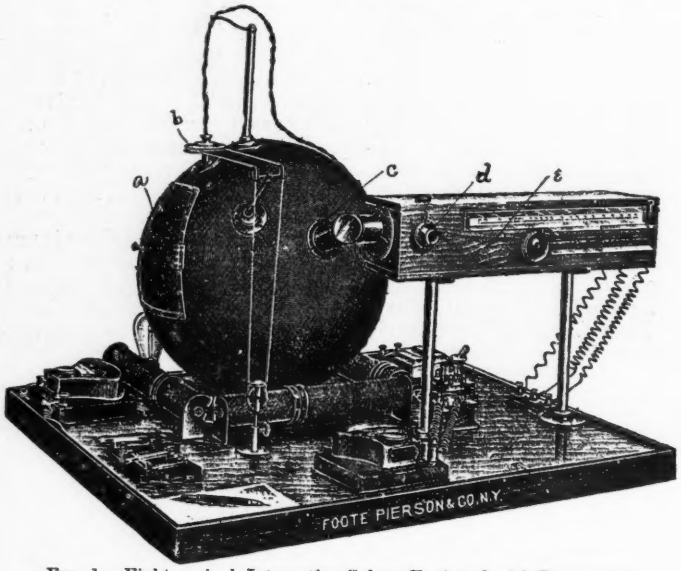


Fig. 1.—Eighteen-inch Integrating Sphere Equipped with Photometer.

obstructed light from the lamp falls upon that portion of the interior surface of the sphere which is opposite the window, the latter is brighter than when the same area of the sphere is covered by the shadow due to the opacity of the side of the lamp bulb which is painted black. This result indicates that the illumination of the window is influenced too little by the light which falls upon the opaque screen. Examples showing the extent of this effect appear in the following :—

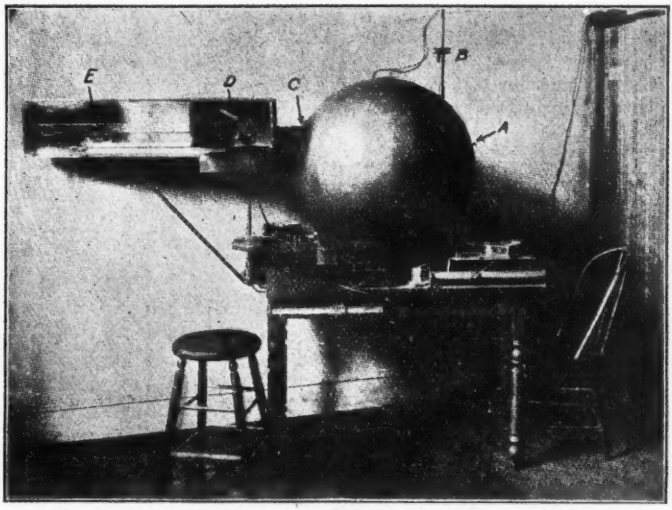


FIG. 2.—Thirty-inch Integrating Sphere Equipped with Photometer.

DECREASE IN WINDOW ILLUMINATION WHEN SHADOW FROM LAMP BULB FALLS UPON SIDE OF SPHERE OPPOSITE WINDOW.

Diameter of sphere Inches.	Per cent decreased window illumination.
18	11
30	6
80	negligible.

The screen must be of sufficient size to screen effectually all parts of the light-source from the window. Since it is desirable to use always one and the same screen, it is necessary to employ a screen approaching in size the largest light-source to be tested, the particular size varying with the location of the screen in the sphere. Under these circumstances, it has been found that when an opaque screen is used, the accuracy of results is dependent upon the size of the light-source tested. So, for example, in the 80 in. sphere the following differences have been found between results obtained with an opaque screen of the size which it is desirable to use, and those obtained with the smallest opaque screen which could be used in connexion with the particular light-source investigated.

Lamp.	Per cent difference between determinations with large and small opaque screens.
100 c.p. carbon filament	2
32 c.p. carbon filament	3
16 c.p. carbon filament	4
8 c.p. carbon filament	5
4 c.p. carbon filament (sign lamp)	10
2 c.p. carbon filament (sign lamp)	10

These data indicate that if an opaque screen were used an arc-lamp with an opal globe would receive an undue advantage in comparison with the same lamp equipped with a clear glass globe.

Errors due both to opacity of the screen and to variations in the relation between its size and that of the light-source may be eliminated by substituting for the opaque screen one of a par-

ticular translucency. The correct translucency must be arrived at empirically. It varies with sphere-diameter and with the screen-location. When a screen of correct translucency is obtained, a lamp with distorted light-distribution, as described above, will illuminate the window uniformly, irrespective of its orientation, and correct testing of lamps of different sizes may be made.

PRACTICAL OPERATION OF THE SPHERE.

In using the integrating sphere, entire reliance must be placed in the "substitution" method of photometry. If the "substitution" method could be followed implicitly, the dimensions, screening, &c., could be varied with impunity. Correct design becomes most important as lamps which are to be tested vary in type, size, and distribution characteristics. Substantially correct results could probably be obtained, from an inaccurate sphere if standard lamps, whose total light-flux had been determined by other approved methods, were available in sizes and types similar to those which were to be submitted to test. As, however, it is not practicable to keep available a large supply of standardized lamps of various sizes and types, correct design is imperative.

Fortunately the result is attainable with much less difficulty than that experienced with almost any other photometric appliance. In even the smallest spheres with which the authors have had experience, after a proper screen had been found, little difficulty has been encountered in determining the mean spherical candle-power or total light-flux of any of the varied shapes of filaments encountered when the sphere had been standardized by a lamp of any particular filament shape; that is to say, even in a sphere so small as 11 in. in diameter, when correctly designed, the brightness of the window has been found to be independent of such differences in light-distribution as are met with in practice. If, however, it is desired to test frosted lamps in one of the smaller spheres, then standard frosted lamps must be provided. If it is desired to test lamps having discoloured bulbs, standardized lamps in like condition must be used. If this is not done a slight error may

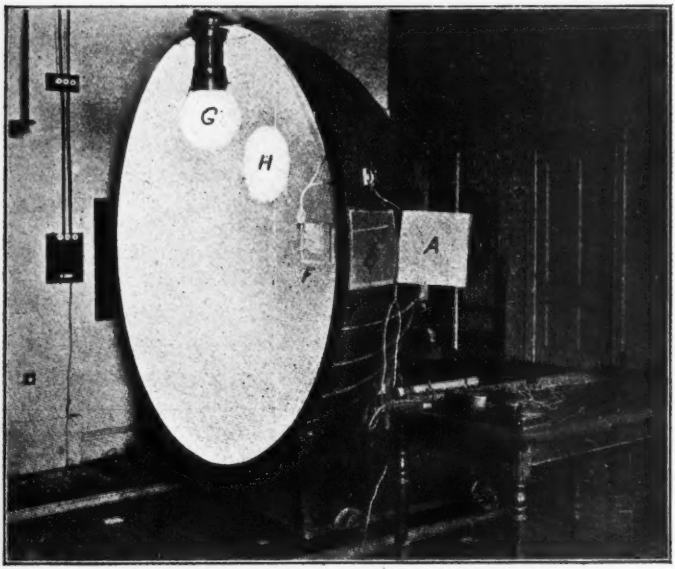


FIG. 3.—Interior of Eighty-inch Integrating Sphere.

be encountered. This error becomes negligible in spheres 18 in. in diameter and larger.

ADVANTAGES OF THE SPHERE.

In practice the integrating sphere has been found to be a very practical device, possessing the following advantageous features :—

Simplicity of construction.—The parts are few and easily built. There is an entire freedom from the complication which has been the blight of other integrating photometers.

No adjustment of parts necessary.—A sphere, when correctly designed, needs no adjustment. The only thing likely to change is the character of the interior surface, the coating of which may have to be renewed from time to time. The only attention required is occasional cleaning to prevent dust from destroying the surface for photometric purposes.

Absence of flicker due to rotation of lamp.—This fact means higher precision and higher speed in photometric settings.

Greater facility in arc-lamp tests.—Since the total flux of light is utilized in the integration, all effects due to the wandering of the arc are minimized.

Elimination of breakage due to rotation of lamp.—A very important item, as those who have conducted tests upon metallic filament lamps can attest.

May be used in a light room where necessary.—This fact renders the use of the sphere practicable where other photometers could not be employed because suitable dark rooms are not to be had.

Higher accuracy than other integrating photometers.—A number of causes contribute to this greater accuracy. It is superior to photometers of the Matthews type, in that it gives a true integration of the light rather than a summation. All values of the luminous intensity of the lamp are taken account of, while in the Matthews type some important values may be omitted altogether and have no influence on the result. An example of this advantage has been seen in tests of magnetite arc-lamps.

The need for a practical apparatus for the determination of total light-flux has been emphasized of late years by the advent of many and varied forms of illuminants and by the impetus given to the study of light-sources and illumination as a result of the movement which culminated in the formation of the Illuminating Engineering Society. The comparison of different light-sources which has become most necessary and desirable in late years can be made with the closest approach to fairness, principally through a consideration of the total light-flux in terms of which best statements of lamp efficiencies can be made. The study of illuminating efficiencies is best facilitated through consideration of the light-flux. This involves a statement of the total light-flux of sources. Thus the study of both the production and the utilization of light is creating a demand for a simple means of determining light-flux. This means appears to be available in the integrating sphere.

DISCUSSION.

Mr. F. E. Cady asked if any investigations had been made as to the effect of dust on the interior of the globe.

Mr. H. Thurston Owens asked if the photometer had been used for gas-lamps.

Mr. A. A. Wohlauer inquired whether the theory of the globe could be applied to the predetermination of illumination due to walls and ceilings.

Dr. Clayton Sharp, in reply, said that dust ought not to be allowed to accumulate; however, if the substitution method is employed the properties of the globe as a whole ought not to be seriously prejudiced.

With a large sphere—having a detachable cover and an aperture at the bottom to promote the free circulation of air in the globe—gas-lamps would be tested in a satisfactory manner.

With regard to Mr. Wohlauer's query, he did not think the constant of the sphere could apply in the same way as those calculated by Mr. Lansingh and others for the illumination of a room, with reflecting walls and ceiling, the constants in this latter case being obtained in an entirely different way.

The Calculation of Illumination by the Flux of Light Method.

By J. R. Cravath and V. R. Lansingh.

(Abstract of Paper presented at the Second Annual Convention of the Illuminating Engineering Society, Philadelphia, October 5-6th, 1908.)

This paper presents certain methods employed by the authors in calculating the illumination of large interiors, and is intended to show the practical application of the suggestions made by Dr. Clayton H. Sharp in his Presidential Address before the First Annual Convention of the Illuminating Engineering Society at Boston, July 30th, 1907.

In this paper no attempt is made to describe in detail the methods of calculating illumination which were common previous to the time Dr. Sharp delivered his address, and which are now generally used. The most common method where accurate calculations were made was to plot a rectangular curve of illumination with the polar photometric curve of a single lamp as a basis. If there were a number of sources of light in a room the distance of each from any given point was determined, preferably, by a drawing made to scale. By adding together the illumination obtained from the various sources the total illumination on any one point could be found. The principal drawback of this method is the amount of labour involved. Moreover, to approximate to the true average illumination on a working plane, one must select a sufficient number of points equally spaced over the entire plane. The illumination must be calculated or measured for all these, but a true result is only reached by considering *both* the intensity at each point and the extent of the area over which it is distributed.

The suggestion advanced by Dr. Sharp was to the effect that the total amount of flux of light given out from the lamps should be calculated in lumens to determine the amount of light available, and that the average intensity of illumination in foot-candles on the working plane it is desired to illuminate be determined from the number of lumens falling on that plane.

The number of lumens given out by a lamp is the mean spherical candle-power multiplied by 12·57. In illuminating engineering calculations one is concerned principally with the flux of light, or, in other words, with the number of these lumens which fall upon a certain plane commonly referred to as the working plane. For example, in a large store, the working plane would be considered as being even with the tops of the counters, or about 42 in. from the floor. In a large general office room it would be the plane of the desk-tops, about 30 in. from the floor.

The lumen being that flux of light which will produce an average illumination of 1 foot-candle over a surface of 1 ft. square, it easily follows that if the total number of lumens emanating in the direction of the working plane and the number of square feet in the plane are known, we can easily arrive at the average foot-candle intensity by dividing the total number of lumens by the square feet in the room or plane. Thus, if there are 300 lumens falling on a plane of 100 sq. ft. area, there is an average intensity of 3 foot-candles over that plane.

To make practical application of these principles in the calculation of illumination it is necessary to determine with approximate accuracy the number of lumens given out from the lamps in the direction of the plane to be illuminated. When this is determined it is then necessary only to add together the number of lumens directed toward the working plane by all of the lamps in a room, and to divide this total by the number of square feet in the room to get the average foot-candles on the working plane.

This method, of course, takes no account of the lumens directed toward the ceiling and walls, a part of which ultimately reach the working plane by reflection. This element of uncertainty, however, is the same as that which accompanies other methods of calculation heretofore used. Of course, in the majority of cases a certain proportion of the total number of lumens given out by the lamps is needed to illuminate ceilings and walls. Except where opaque reflectors are used, this portion of the problem can usually be neglected, because the ordinary opal, prismatic, and sand-blasted reflectors let through enough of the total lumens given out by a lamp to take care of ceiling and wall illumination.

This method further takes no account of the variations between maximum and minimum illumination which may exist in different parts of a room; and, in a large low room with a very few large sources of light, this method would not be of much value. Fortunately the number of rooms lighted in this way is on the decrease.

It is well to describe rapid methods for determining the number of lumens given out in different zones about a lamp. Assuming that the distribution of light about each lamp is practically symmetrical with reference to the axis of the lamp, and that the lamps are to be placed with axes vertical (these being the conditions now commonly prevailing with high candle-power incandescent lamps, Nernst lamps, and arc-lamps), it is very easy to determine the number of lumens given out within a certain number of degrees from the

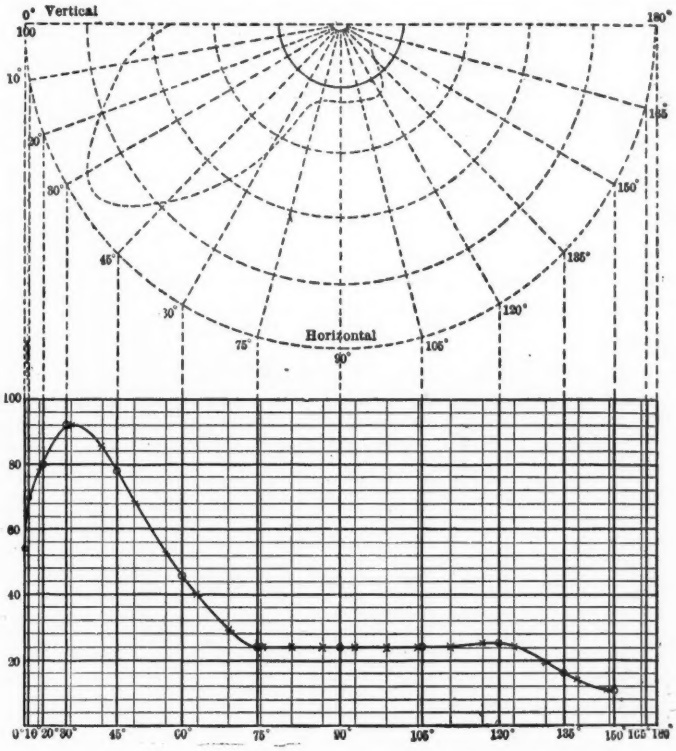


FIG. 1.—Rousseau Diagram for Gem Lamp with Bowl Reflector.

lamp axis or perpendicular. One of the quick ways to determine the lumens is to plot a Rousseau diagram.

The method of preparing Rousseau diagram paper is indicated by Fig. 1, in which the full lines represent the preferable Rousseau diagram ruling, and the dotted lines indicate the method by which the ruling is obtained. Rousseau diagram paper already ruled is now easily obtainable. In Fig. 2 is shown a Rousseau curve plotted for a Gem lamp of 50 mean horizontal candle-power in a prismatic bowl reflector. The polar co-ordinate candle-power curve, commonly known as the photometric curve of the same lighting unit, is also shown. The area of this curve shown in Fig. 1, the ruling is such that there are twenty equal divisions of the diagram as measured horizontally. As the average height of the curve represents candle-power, the horizontal distance instead of 20 should be 12·57, if the area is to represent lumens. The constant by which the sum of the candle-power readings must be multiplied in order to get the lumens in this case is, therefore,

$$\frac{12{\cdot}57}{20} \text{ or } 0{\cdot}62.$$

The author next proceeds to describe a further short cut which obviates the necessity of plotting a Rousseau curve, by the aid of a set of flux polar diagrams

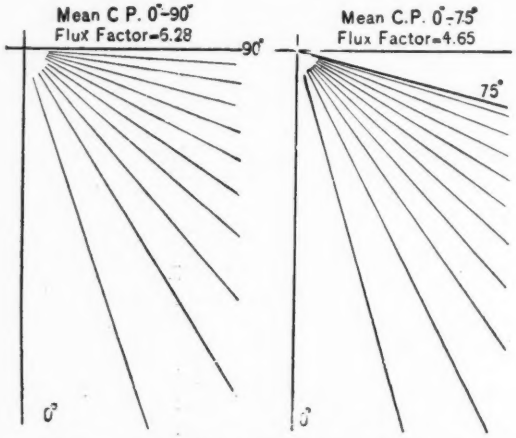


FIG. 2.—Flux Polar Diagrams 90 and 75 degrees.

Rousseau diagram between any two vertical lines representing degrees corresponds to the total flux of light in lumens given out in the zone bounded by those degrees. For example, the area enclosed by the curve between zero and 90 degrees (90 degrees being horizontal) represents graphically the number of lumens given out in the lower hemisphere; while the area enclosed by the whole curve from zero to 180 degrees represents the total number of lumens given out. To determine the number of lumens from the Rousseau diagram it is necessary only to ascertain the area enclosed by the curve expressed in proper terms. In the Rousseau with radial lines corresponding to the positions of the equally-spaced lines on the Rousseau diagram. Such a flux polar diagram for an angle of 90 degrees is shown in Fig. 2. If this diagram is made on transparent celluloid or tracing cloth, it can be laid over the ordinary polar-photometric curve with the zero line at the vertical and the 90-degree line at the horizontal. By noting and averaging the candle-power of the photometric curve at the ten points where the radial lines (not including the zero and 90-degree lines) cross the photometric curve, the mean hemispherical candle-power is obtained. As there are ten readings to be averaged,

it is only necessary to add the readings and transfer the decimal point one figure to the left to obtain the average. This mean value of hemispherical candle-power multiplied by the flux factor 6·28 for the 90-degree zone, gives the total number of lumens in the lower hemisphere. Similar polar flux diagrams can be prepared for other zones. With a set of these flux polar diagrams, the illuminating engineer is in a position very quickly to find the lumens from any symmetrical photometric curve within any of the zones which are of practical use to him.

the other hand, in a very large room with few obstructions and light coloured walls, the light which emanates from the source at a considerable angle from the vertical ultimately falls on the working plane and becomes useful. The area illuminated by each lamp is very large in such a case, and each point in the working plane receives illumination from many lamps.

There is given herewith a table of constants based on all of the results of reliable tests on efficiency of illumination which have come to the notice of the authors. This table shows the

Table Showing Number of Watts Per Square Foot of Floor Area Required to Produce an Average of One Foot-Candle of Illumination—Watts Per Lumen.

INCANDESCENT LAMPS.	
Tungsten lamps rated at 1·25 watts per horizontal candle-power; clear prismatic reflectors, either bowl or concentrating; large room; light ceiling; dark walls; lamps pendant; height, 8 to 15 feet	0·25
Same with very light walls	0·20
Tungsten lamps rated at 1·25 watts per horizontal candle-power; prismatic bowl reflectors enamelled; large room; light ceiling; dark walls; lamps pendant; height, 8 to 15 ft.	0·29
Same with very light walls	0·23
Gem lamps rated at 2·5 watts per horizontal candle-power; clear prismatic reflectors, either concentrating or bowl; large room; light ceiling; dark walls; lamps pendant; height, 8 to 15 feet	0·55
Same with very light walls	0·45
Carbon filament lamps rated at 3·1 watts per horizontal candle-power; clear prismatic reflectors, either bowl or concentrating; light ceiling; dark walls; large room; lamps pendant; height, 8 to 15 feet	0·65
Same with very light walls	0·55
Bare carbon filament lamps rated at 3·1 watts per horizontal candle-power; no reflectors; large room; very light ceiling and walls; height, 10 to 14 feet	0·75 to 1·0
Same; small room; medium walls	1·25 to 2·5
Carbon filament lamps rated at 3·1 watts per horizontal candle-power; opal dome or opal cone reflectors; light ceiling; dark walls; large room; lamps pendant; height, 8 to 15 feet	0·70
Same with light walls	0·60
ARC LAMPS.	
5-ampere, enclosed, direct-current arcs on 110-volt circuit; clear inner, opal outer globe; no reflector; large room; height, 9 to 14 feet	0·50

It remains to determine how closely the results calculated as above agree with actual results obtained in installations which have been tested. The main chances of error in the above method lie in the reflection from walls, and in assuming too large or too small an angle from the vertical in which to determine the flux of useful light. In a small room with very dark walls and the lamps placed high, the zone of useful light as measured by the angle from the vertical would be small, sometimes not over 50 or 60 degrees. On

watts per lumen, or, in other words, the watts per square foot required to give 1 foot-candle average illumination in several types of lighting installations.

To apply it use the rule—

Watts per sq. ft.=foot-candle intensity ×constant from table.

The methods described above are only approximate at best, but probably they are no more open to error than other methods. They are certainly much more simple and rapid. The authors have used them for the past year.

DISCUSSION.

Mr. R. L. Lloyd, who said he was interested in the matter from a practical standpoint, mentioned the case of a concert-hall in his city, in which he had considered the lighting plant meagre and insufficient. He, therefore, attempted to work out a scheme based on the figures and tables published by the Illuminating Engineering Society, and although he had felt some little doubt as to whether the lights contemplated would suffice, they were actually found to be ample.

Dr. Bell remarked that this was an illustration of the work the Society were carrying out.

Mr. J. S. Codman drew attention to some figures in the table given by Mr. Lansingh, relating to the Gem and tungsten lamps. The tungsten lamp gave practically twice the light yielded by the Gem for the same power; why, therefore, were the watts per square foot, under apparently similar conditions, slightly more than twice as great in the case of the Gem lamp?

Strictly, however, if mean spherical candle-power be considered, the actual efficiency of the tungsten lamp worked out to about 1·86 times that of the Gem. It was possible that the reflecting power of the walls might differ somewhat in the two cases, owing to the "whiter" nature of the tungsten lamp.

Mr. T. W. Rolph gave a table of the angles at which readings could be taken to obtain the mean candle-power of lamps, in accordance with flux-polar diagrams devised by Mr. Lansingh.

Mr. A. A. Wohlauer referred to the apparent discrepancy between the results for the Gem and tungsten lamps, which he thought might be explained by the method of taking into account the light reflected from walls and ceilings in the two cases. The general value of the constants given, however, was in accordance with his experience.

Mr. P. S. Millar said the authors had taken up Dr. Sharp's suggestion as regards the use of the conception of flux of light in a very practical way. The ratio between the flux of light applied to a specific purpose and the total flux generated was a most useful factor in illuminating engineering, especially in the prediction of the results in rooms of various sizes; he hoped that the authors would take up this question in an equally thorough manner during the next year.

In reply, **Mr. V. R. Lansingh** drew attention to the desirability of using the term "lumens per watt," instead of the reversed expression, which, of course, was not a measure of efficiency at all; he and Mr. Cravath, at any rate, meant to persist in the correct term, and hoped others would help to reverse the present practice.

In reply to Mr. Codman's query he found it difficult to give any precise explanation, but one reason was that Gem lamps did not always run as they were rated; also colour-values might affect the matter.

With regard to Mr. Wohlauer's question, he wished to point out that his results were founded on actual practical experiment, and took into account the flux of light from the ceiling; but it was interesting to compare them with those obtained by the theoretical methods described in this paper.

Mr. F. W. Willcox, referring to Mr. Lansingh's suggestion regarding the method of expressing efficiency, said that the reason for adopting "watts per candle" was a practical one, in that it enabled us to deal with integral unity, and efficiencies were not so readily apparent in a practical form.

Applying the idea to "lumens per watt," he agreed with Mr. Lansingh's suggestion, because "lumens per watt" would be integral in the case of the tungsten lamp.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

A Suggested Standard Specification for Metallic Filament Electrical Glow-Lamps.

(From the *Journal für Gasbeleuchtung*, October 3rd, 1908.)

A DISCUSSION recently took place in Münich on the subject of standard specifications and conditions of photometrically testing metallic filament lamps, under the chairmanship of Herr Paulus, Director of the Laboratory of the Münich Corporation Electric Light Works, the meeting being attended by representatives of various lamp-manufacturing companies, including the Vereinigte Glühlampenfabriken, as well as the Münich Supply Co.

Dealing first with the photometry of metallic filament lamps, it was agreed, in accordance with the result of the researches of Herr C. Paulus, that (except in the case of the tantalum lamp) the rotation method of determining mean hemispherical candle-power was preferable to the angle-mirror method for metallic filament lamps. A speed of 60 revolutions per minute was recommended. It was also recommended that lamps run at a consumption of not over 1·5 watts per H.K. should be used for standard and comparison purposes, in order to secure as nearly the same colour of light as that yielded by the source under test as possible.

The second point under discussion dealt with the question whether the lamps should be tested at the pressure required by the consumer, or at the desired candle-power, the latter method being eventually agreed upon. It was further decided that by the "useful life" of a lamp should still be understood the period of time during which the initial candle-power of the lamp is reduced by 20 per cent. Life-tests by overrunning were unanimously regarded as too uncertain for present recommendation.

The last questions brought up for discussion related to the quantities which were to be marked on the lamp and the permissible margin of variation in them.

Herr Paulus had addressed a circular letter to a large number of electrical supply companies, inquiring (1) whether the actual supply pressure at the outlets supplied was just as often above or below the declared value; and (2) whether the deviations above and below at any prescribed outlet were equally great.

As a result of these inquiries it appeared that, on the average, the pressure was low in the case of 25 per cent of the outlets, and high in the case of 50 per cent; the highest value of the P.D. at any outlet was, on the average, 4 per cent above the nominal value, and the lowest value 2 per cent below.

Most of those present, however, seemed to feel that no rigid recommendation as to permissible voltage-variation could be framed at present, and it was decided that the matter should be the subject of special consideration between the supply company and the lamp-makers. It was further laid down that only the specified voltage was to be marked on each lamp.

The above suggestions, however, were only of a purely tentative character, and are to be the subject of trial in the laboratory of the company in Münich.

Accidents in Factories and Workshops.

WE understand that the Home Secretary has appointed a Departmental Committee to inquire into the causes and circumstances of the increase in the number of reported accidents in certain classes of factories and workshops and other premises under the Factory Acts, and to report what additional precautionary measures are in their opinion necessary or desirable.

The Committee is constituted as follows:

H. J. Tennant, M.P. (chairman);

A. M. Carlisle (of the firm of Messrs. Harland & Wolff);

Sir William D. Cramp, I.S.O.;

A. H. Gill, M.P.;

J. B. Tattersall (president Oldham Master Cotton Spinners' Association, and vice-president of the Federation of Master Cotton Spinners' Associations);

J. S. Taylor (of Messrs. Taylor & Challen, engineers, Birmingham);

Henry Vivian, M.P.; and

Miss Mona Wilson.

The secretary to the committee is Mr. Alexander Maxwell, of the Home Office.

The Wiring and Lighting Equipment of the Stack-Room of a New York Public Library.

By J. F. Musselman.

(From *The Electrical Review*, N.Y., Oct. 17.)

The features of the arrangements in this library seem to be of a special character. The section described is 297 ft. long by 78 ft. wide, and contains about 63 miles of shelves to accommodate 2,700,000 volumes. Naturally security from fire is an important consideration.

Nothing combustible enters into the construction of the room or its furniture, all stacks and shelves being of iron, and all floors of marble slabs.

Special attention has also been given to the lighting of these shelves, in order that the title of any book can be ascertained without any difficulty. Many of these titles are somewhat dim, so that a high intensity of illumination is desirable: 0·7 candle-feet normal to the backs of the books on the lowest shelf was considered sufficient. The control of the various lamps and to illuminate the shelves and the passages between them is sectional, so that it is only necessary to light up the lamps in any particular locality where books are to be handled. Lamps can be controlled either from the centre aisle or the operating desk of the stack-room where the book-lifts to the reading-room are situated. Special lamps are also installed for use by the night watchman.

The interior of the whole stack-room is to be painted an egg-shell white, all conduit work, cabinets, &c., being finished in a similar manner, with the object of rendering the conditions for the distribution of light as favourable as possible. It is stated that the excellence of the arrangements is in no small measure due to the care of the architects —Messrs. Carrere & Hastings—who are responsible for the general design.

Inartistic Flashlight Advertisements.

There seems no adequate reasons why signs should not achieve their purpose of calling attention to some specified object, and yet be contrived in such a way as not only to escape offending artistic taste, but also to serve as an effective decoration. This aspect of the matter was recently emphasized in *The Illuminating Engineer* (Sept., p. 746).

Meantime we observe that a correspondent of *The Architect and Contract Reporter* has been pointing out that the flashlight advertisements on the top of the editorial building, "is a disgrace to Ludgate Circus." The Editor, however, explains that, while agreeing with his correspondent, his periodical has no control over the top of the building: otherwise the objectionable signs would soon be missing.

Scientific Publications Received

We have to acknowledge the receipt of a very interesting and complete illustrated description of the Technische Museum für Industrie und Gewerbe in Vienna.

We have also received two brochures dealing with researches in Germany on the illumination of schoolrooms, &c., by Dr. E. Schilling, of Münich, and Prof. L. Weber, of Kiel. With these we hope to deal in greater detail on a future occasion.

We also take this opportunity of expressing our acknowledgments to those societies whose communications we have received during the past year, including the publications of the American Academy of Science; American Electrotechnical Society; American Institute of Electrical Engineers; American Gas Institute; American Philosophical Society; American Physical Society; Architects, Society of; Arkiv für Matematikoch Fysik (Stockholm); Bureau of Standards (Washington); Civil Engineers, Institution of; Electrical Engineers, Institution of; Faraday Society; Franklin Institute; Jassy, University of (Roumania); Marine Engineers, Institution of; Naturalists, Imperial Society of (Moscow); Smithsonian Institute; Society of Arts, Journal of; Tokio Mathematico-Physical Society; Western Society of Engineers.

The Progress of Electric Incandescence.

By Prof. A. Blondel.

(Abstract of Paper read at the International Electrical Congress at Marseilles, Sept. 14th to 20th.)

A wonderful revolution in electric incandescence has taken place since the last Congress of Electricians in Paris. In 1900 the carbon filament of Swan and Edison still held the supreme position in this domain. It may seem extraordinary that it did not occur to people to utilize the present materials earlier, but it must be recalled that the prevalent impression that Edison had covered the ground so thoroughly as to leave but little room for further effort, discouraged investigation.

During the period referred to (1880 onwards) experiments progressed in a doubly erroneous direction. In the first place, it was then supposed that all that was necessary, in order to make a more efficient filament, was to secure a conducting but highly refractory material. In the second place, there was an impression that one ought to select bodies with a high emissive power. Recent progress in the theory of ionization and incandescence have corrected both these views.

M. Blondel next proceeds to summarize the work of Wien, Lummer, &c., especially emphasizing the result that the efficiency of incandescence is improved by departure from the theoretical black body. For instance, Lummer found shiny platinum to be preferable in this respect, and this advantage is shared by filaments having polished grey surfaces. On the other hand, there is but little evidence of genuine selective radiation such as is attributed to the Nernst filament, and such as occurs is of a trifling character.

The most important point elucidated by the theory of ionization has been the realization of the fact that solid materials, such as carbon, which are relatively infusible, tend to vapourize gradually far below their boiling point. There is, therefore, no object in utilizing a substance for the manufacture of filaments which, though refractory, begin to vapourize at a low temperature. Carbon, as stated above, is open to objection from this point of view, and certain rare metals of high density, such as tungsten, have been found preferable.

M. Blondel next embarks on the historical résumé of methods of manufacture of filaments. He refers to the work of Howell and the development of the Gem metallized filament, and of the Nernst lamp. Many attempts have also been made to manufacture satisfactory filaments of metalloids other than carbon, but they have not been very successful. The chemical methods used in the manufacture of metallic filaments are here inapplicable, and elements of this class tend to form nitrides during construction. Moreover, their density being relatively low, there is no reason to think that the tendency to vapourization of such materials is less marked than that of carbon, but the reverse; and the author, having experimented in this direction in connexion with M. Bainville, subsequently abandoned the method. The Helion lamp, however, seems to have been carried to a further stage of development, and M. Blondel believes that the behaviour of the filament in question can only be explained on the supposition that a eutectic combination of carbon and silicon is formed.

The next section of M. Blondel's paper treats on the development of the metallic filament proper. He enters into the description and classification of the various methods in vogue in exceptional detail. Readers who are interested in this phase of the subject may with advantage refer to the recent article by Dr. F. Jacobsohn in our journal (May, p. 395, and June, p. 463). Naturally, in the space at our disposal, we can only briefly refer to the ground covered by M. Blondel in this paper. It is to be observed, however, that he expressly declines to offer any opinion on the subject of the value of the patents concerned.

The first method referred to by M. Blondel is that of simply drawing out the metal, of which the most conspicuous example is the Tantalum lamp, largely due to the work of Dr. von Bolton. The diameter of such filaments, however, is practically limited by the size of the aperture through which they are drawn, and this could hardly be reduced below about 0·04 to 0·05 mm., while a diameter of as low a value as 0·02 mm. is attained in the case of the tungsten lamp.

The second method is that of Kuzel, who prepares filaments by the manipulation of metal in a colloidal condition, lamps made by this process being sold under the name Sirius.

A third method, originally employed by Auer, is that of decarburation. This involves the manufacture of paste filaments mixed with some organic ingredient of a binding character, which is subsequently removed chemically.

Fourthly may be mentioned the suggested construction of filaments by chemical composition of a binary compound of the desired metal, *e.g.*, sulphides or oxides of molybdenum. Theoretically this method has the advantage that by subsequent chemical treatment of the compound the filament should shrink and render the production of thin filaments simpler. A number of patents have been taken out for processes of this description by Lux and the A.E.G., &c., but the method is attended by great practical difficulties.

Among other indirect methods we may recognize that of Cruto, and recently of Just and Hanaman, who proposed to deposit the desired metal upon a carbon core, and subsequently to decarburize the whole.

Other workers have developed a substitution method, according to which both the processes taking place in the above method are in operation simultaneously. This system has been attempted by F. Blau and the Auer Society, but it does not lend itself well to the manufacture of very thin filaments.

Lastly, mention may be made of a "cementation" process devised by Kuzel, which involves the formation of a eutectic skin alloy, with the object of increasing the resistance of a filament, and incidentally altering the quality of the light emitted.

Among the difficulties incidental to the manufacture of metallic filaments the author includes :—

1. The fact that the operation of forming a metallic filament in an atmosphere of hydrogen, &c., is a more costly and complicated process than the corresponding treatment of ordinary carbon ones.

2. The extreme thinness of the metallic filament, which renders the mounting of it very difficult, and the transport difficulties to which this gives rise.

3. Difficulties attending the mounting of a number of filaments within the same bulb; in this respect the single filament employed in the Tantalum lamp is a great advantage.

4. As a metallic filament in general consists of isolated metallic particles melted together, it is extremely fragile and easily broken by vibration; the fragility increases with the life of the lamp, rendering the duration of the latter very uncertain.

5. The softening of the filament in the hot state renders the manufacture of a lamp which will burn in any position a matter of some difficulty.

6. Another difficulty previously experienced was the problem of successfully attaching the filament to the leading in wires by the aid of a carbonaceous or metallic paste. At the present day this method is not employed; the filament is directly attached by the production of a miniature arc between the contacts, thus avoiding the tendency towards carbonization and occluded gases

The remaining portion of this paper is devoted to a survey of the main properties of the metallic filament lamps and their applications in practice. The author gives particulars of the connexion between pressure and candle-power, change of resistance, &c., of the various lamps on the market, their behaviour on alternating current circuits and the distribution of light; the Tantalum and tungsten lamps, on account of their vertically situated filaments, yield polar curves of distribution approximating to the law $I_a = I \cos_h a$.

Tables are also given comparing the running costs of the various types of metallic filament lamps with that of gas, and the paper concludes with a brief discussion of the best method of treating 220-volt circuits, the use of transformers, and the grouping of lamps in series, as exemplified by the Stearn system.

White Lights for Ships and Lighthouses.

Dr. H. J. Claiborne, in a recent number of the Quarterly of the United States Naval Institute, proposes an interesting departure in the existing methods of arranging night lights on ships, &e.

He seems to suppose that colour blindness is of much more common occurrence among those at sea than is generally credited, and that it is also no easy matter to devise tests to exclude the possibility of all dangerous cases being detected. Yet at sea, the confusion of colour—a mistake as regards the colour of the port and starboard lights of a ship, for instance may readily give rise to serious results.

He therefore suggests that the use of colour for distinguishing port and starboard lights, &c., should be abandoned, and that geometrical patterns of white lights, such as even the colour blind could easily distinguish and identify, should be substituted.—*The Electrical Review of New York.*

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

The subject of photometry received some attention at the annual meeting of the American Gas Institute. The report of the joint committee of the Illuminating Engineering Society and the Institutes of Gas and Electrical Engineers, relating to AN INTERNATIONAL UNIT OF LIGHT, was submitted by **Mr. Gartley**; these recommendations had previously been presented at the second annual convention of the Illuminating Engineering Society. While viewing sympathetically the suggestions of .the committee, the Institute decided to postpone definite decision in the matter until the data afforded by the Bureau of Standards, relating to the ratio between the British and United States candles, were completed, as it was hoped they would be shortly.

At the same meeting **C. O. Bond** presented a very comprehensive paper on the PHOTOMETRY OF GAS, in which he reviewed the history of the different flame standards in different countries. Special stress was laid on the necessity for adequate ventilation of photometer-rooms. The pentane standard was recommended, but the author thought there was also an opening for something less expensive. In conclusion, it was urged that the Institute should devote themselves to the consideration of the testing of candle-power of incandescent mantles and their standardization generally.

Kohler (*Z. f. B.*, Nov. 10th) describes a form of radiometer for comparing the HEAT-RADIATION OF GLOW-LAMPS. He suggests that this arrangement could be used, with caution, for the comparison of the intensity of lamps of the same nature; it is pointed out, however, that the readings of such an instrument gradually alter for some time after a lamp is switched on, owing to the heating up of the bulb.

C. Hering (*Illum. Eng.*, N.Y., Oct.) again discusses the question of the definition of the SPHERICAL CANDLE-POWER and the LUMEN. This matter was brought up at the recent convention of the Illuminating Engineering Society. Considerable differences of opinion seem to exist on the point. Hering argues that "spherical candle-power" is of the same dimensions as "flux of light," being connected by the relation:

$$\text{flux} = 4\pi \times \text{spherical candles.}$$

At a meeting of the society referred to, however, Dr. Clayton Sharp objected to this view, contending that spherical candle-power really merely represented an intensity and not flux. That such difference of opinion should still exist on the subject of the fundamental units of illuminating engineering, only shows, as *The Illuminating Engineer* remarks, that the subject is in want of scientific study, in order that all mistiness as to the nature of the terms used should be cleared up. Another matter referred to by C. Hering is the fact that in many cases the lumen is defined on the basis of the Continental light-unit, while in America the U.S. unit is understood. In this matter he advocates the general adoption of the same convention as that of the Bureau of Standards, with whom it is customary to express results in the U.S. standard of light.

The subject of the ULTRA-VIOLET RAYS IN ARTIFICAL ILLUMINANTS continues to receive attention in different quarters. Thus **A. Bainville** (*L'Electricien*, Nov. 7th) gives a résumé of the suggestions of Drs. Schanz and Stockhausen. **Granjon** (*Rev. des Eclairages*, Nov. 15th) likewise discusses the subject, but considers that the suggestion that there is anything to fear from these rays in ordiary illuminants is exaggerated, though, of course, it is quite right that precautions should be taken in the cases of sources known to be exceptionally rich in energy of this description.

O. Vogel (*Elek. Anz.*, Nov. 10th, Nov. 20th) gives an interesting account of the development of SOURCES OF LIGHT FOR THERAPEUTIC USE. He draws a distinction between the BLUE AND ULTRA-VIOLET regions of the spectrum, and suggests that light between 590 $\mu\mu$ and 350 $\mu\mu$ is the variety that is serviceable in this connexion. In particular he contends that it is mainly the BLUE that is valuable for deep-seated physiological action, and this was realized by Finsen. Very small wave-length ultra-violet light, though causing evident excitation of the outer epidermis, does not penetrate so deeply, and its action is, therefore, not sufficiently deep-seated to destroy germs, &c.

Among articles on general illumination mention must be made of that by **Bloch** (*J. f. G.*, Nov. 2nd), who gives an account of the ILLUMINATION OF THE STREETS OF BERLIN by high pressure inverted gaslights and new flame-arcs, and especially by the new white flame-arcs utiliz-

ing upright carbons. He states that neither method is invariably best. Each case must be considered on its merits, as *both* gas and electricity have made great progress.

J. F. Musselman (*Elec. World*, N.Y., Oct. 17th) describes the EQUIPMENT OF A NEW YORK LIBRARY. Special arrangements are made to render the building absolutely secure against fire, and special night-circuits are installed. The illumination of the stack-rooms seems to have also been the subject of special care on the part of the architects, the general scheme of decoration being in white, and arrangements being made to secure that the titles of all books on the stack-shelves can be clearly read.

An interesting possibility in lighting is dwelt upon in a recent number of the *Electrical World*, namely, the ILLUMINATION OF LARGE OUTDOOR SPACES by artificial light. Some illustrations are presented, showing the lighting of the grounds by small 6 ampere arc-lamps, slung overhead on wires, during the military tournament and cattle-show recently held in St. Joseph, Mo. The order of illumination is said to have approached that in good interior lighting, involving the expenditure of about 0·5 watts per square foot of ground area.

GAS, OIL, AND ACETYLENE LIGHTING, &C.

A SUBJECT of a considerable amount of discussion in the technical press has been the TAX ON GAS AND ELECTRICITY PROPOSED IN GERMANY, regarding which further particulars are now available. It seems to be intended to impose a tax of about 1½*d.* per 1,000 cubic feet on gas, and the equivalent of one penny on incandescent mantles, and there are corresponding rates to be levied on electricity.

Among papers that have been read attention may be drawn to that by **T. J. Litle** at the Annual Meeting of the American Gas Institute (U.S.A.). The author dealt with GAS LIGHTING in a general and practical manner, paying special attention to show-window illumination, and the use of concentrating reflectors for this purpose. As an illustration of the illumination of interiors, mention was made of the problem of satisfactorily lighting a bowling alley.

Owing to the nature of the distribution of light from inverted mantles the author recommended that they should always be placed high up.

Finally he contends that an up-to-date gas company ought to retain one member on their staff who is specially competent to deal with problems of illumination.

Schumann (*J. f. G.*, Oct. 24) describes the results of some investigation into GAS ILLUMINATION IN MUNICH, including that in the streets, where values ranging from 0·2 to 0·3 lux were obtained in one case, and in certain school-rooms, where a range of illumination of 31 to 115 lux, with a mean value of 60 was obtained in one instance.

For school rooms the author emphasizes the need for good diffused systems of lighting, and states that the method of "semi-diffused" inverted lighting, with distributing bowls is preferable, because of the rapidity with which the reflecting power of the ordinary ceiling deteriorates.

Two recent articles in *The Illuminating Engineer* of New York call for mention.

H. Thurston Owens discusses the development of the LANTERN AND LAMP-POST used for STREET LIGHTING BY GAS; these two items, he suggests, ought not to be considered separately, but to be developed in such a way as to present an artistic whole.

E. L. Elliott discusses the DESIGN OF FIXTURES FOR GAS from the artistic standpoint, remarking that many fixtures of to-day are obviously merely adaptations of older styles. Gas, he says, has certain properties that enable fixtures designed for its use to be quite as effective as those for electric light, and he thinks it is undesirable for the design to imitate electrical development instead of proceeding on original lines.

Among other papers of general interest mention should be made of the PRESIDENTIAL ADDRESS of **Dr. A. C. Humphreys** at the annual meeting of the American Gas Institute; the report of the Committee on the international unit of light is mentioned elsewhere in this review.

A recent paper by **F. Haber** (*Z. f. B.*, Nov. 20) contains a detailed and interesting discussion of the structure of the Bunsen flame.

Recent numbers of the *Zeitschrift für Beleuchtungswesen* again contain short descriptions of a series of recent patents of interest. One of these deals with a type of MANTLE THAT IS NOT "BURNT OFF" initially: others deal with burners for the use of LIQUID COMBUSTIBLES. A recent number of *The Gas World* contains a reference to a NEW TYPE OF SELF-LIGHTING MANTLE, little red strips being attached which become incandesent when impinged upon by a stream of gas; this action is said to be preserved for several months.

The last number of *Acetylene* contains an abstract of a recent article on the subject of VILLAGE LIGHTING BY ACETY-

LENE. This may be accomplished by the aid of local generators placed inside each lamp-post, or preferably, by the use of renewable cylinders of dissolved acetylene.

ELECTRIC LIGHTING.

In the electrical press the proposed imposition of a TAX ON ELECTRICITY for power and lighting and ON ELECTRIC LAMPS has been the occasion of much comment, and a recent number of the *Elektrotechnische Zeitschrift* contains a study of the results of a similar tax in Italy.

The author sums up his conclusions by remarking that while it is hard, for various reasons, to tell definitely what the effect of the tax on electricity for lighting has been, there can be no doubt as to the hindrance it exerts on the development of electrical heating and cooking devices. In addition it is stated that the tax is a source of constant friction between the authorities and the local residential engineer, and that the smoothness with which the arrangements for its collection work depend very greatly on the ability and tact of the assessor.

There have been a number of articles, dealing generally with electrical developments, of exceptional interest. Thus **M. L. Flesch** (*L'Electricien*, Oct. 31, Nov. 7) contributes an up-to-date general review of the RECENT DEVELOPMENTS IN ARC AND GLOW LAMPS and mercury vapour lamps; the article contains some interesting remarks on the subject of the Nernst lamps, and the distinction between conductors of the first and second class, and the methods that have been suggested to render the Nernst filament (a second-class conductor) conducting.

E. Eichel (*Elek. Anz.*, Oct. 22 and 25) deals with the field of novel developments in electric lighting in the United States. He surveys the development of the magnetic arc, the mercury vapour lamp and other sources which have found more extensive use in the United States than in Germany.

One system of lighting he refers to is perhaps not very generally known in Europe: namely, the use of HIGH CANDLE-POWER METALLIC FILAMENT LAMPS IN SERIES on a constant current circuit, supplied by stepping down from a high alternating P.D. by means of a constant current transformer.

This system also finds application for the lighting of large open spaces, parks, &c.

B. Duschnitz (*Elek. Anz.*, Nov. 8 and 19) continues his exhaustive résumé of RECENT PATENTS on the subject of GLOW-LAMP MANUFACTURE. In the course of the present instalment he mentions what seems a very singular experience on the part of the Auer Co.

This company had experienced considerable trouble from a tendency of the glowing metallic filaments of lamps to warp in process of manufacture. This effect was traced to the action of the earth's field on the plastic glowing filament, and ceased when the earth's field was neutralized. They therefore take out patents covering methods of counteracting the effect by screening the lamp being tested with a suitable iron surrounding cover, or other means of prevention.

Several articles by **R. Boehm** and others likewise deal generally with recent progress in glow and arc lamps.

The use of transformers in connexion with low P.D. metallic filament lamps continues to excite some attention. *Electrical Engineering* for Oct. 29 contains an article on the WIRING OF 25 VOLT CIRCUITS, and it is stated that some of the buildings of King's College (London) have been completely converted to 25 and 50 volts respectively. A recent editorial note in an American journal, however, raises the question of the probable effect on the power factor of the service of the general adoption of a large number of small transformers on the lighting load.

E. Besser and **H. Remane** contribute correspondence to the *Elektrotechnische Zeitschrift* on the subject of the effects of OVERRUNNING METALLIC FILAMENT GLOW LAMPS.

Schreiber (*E.T.Z.*, Nov. 5) discusses the design of LAMPS AND FITTINGS FOR USE IN MINES. He recommends that portable lamps to be employed in this connexion should invariably be protected both with a stout glass envelope and a basket work wire covering.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Bainville, A. Sur le danger qui presentent les sources lumineuses à grand rendement (*l'Electricien*, Nov. 7).
Basset Jones. Symbolism and Art (*Illuminating Engineer*, N.Y. Oct.).
Bell, L. The Measurement of Street-Illumination (*Elec. World*, N.Y., Oct. 24).
Bloch, L. Die neuesten Fortschritte der Berliner Strassenbeleuchtung in Vergleich mit den bisherigen Beleuchtungsarten, (*J. f. G.*, Nov. 7).
Bond, C. O. Some further remarks on the Photometry of Gas (*Am. Gaslight Jour*, Oct 26).
Cornell, N. A. The Wiring and Illumination of the Hudson River Tunnel (*Progressive Age*, Oct. 19).
Editorials. The Cost of Street-Illumination (*G. W.*, Nov. 7).

The Second Annual Convention of the Illuminating Engineering Society. The Meaning of Photometrical Units. The Annual Meeting of the American Gas Institute. Illuminating Engineering as an Art. Fake Illuminating Engineering. (*Illuminating Engineer*, N.Y., Oct.).
Colour Analysis of Illuminants (*Elec. World*, N.Y., Oct. 24).
An International Unit of Light (*Rev. Electrique*, Nov. 15).

Granjon, A. Les Effets de Lumière Artificielle sur la Vision (*Rev. des Eclairages*, Nov. 15).
Hering C. The Spherical Candle versus the Lumen (*Illuminating Engineer*, N.Y., Oct.).
Kohler. Ueber einen Apparat zum Messen der Warmestrahlung elektrischer Lampen (*Z. f. B.*, Nov. 1).
Musselman, J. F. Wiring and Lighting Equipment of a New York Public Library (*Elec. World*, N.Y., Oct. 17).
Thurston Owens. Street-Lighting in Brooklyn (*Progressive Age*. Oct. 15).
Vogel, O. M. Blau oder Ultraviolet? (*Z. f. B.* Nov. 10, Nov. 2).
The Illuminating Engineering Society (*Elec. Rev.* Oct. 25, *Elec. World*, Oct. 17).
The Lighting of Large Outdoor Areas (*Elec. World*, Oct. 31).
America and a Unit of Light (*J. G. L.*, Nov. 10).

ELECTRIC LIGHTING.

Besser, E., and Remanè, H. Einfluss von Spannungsüberschreitungen auf die Lebensdauer von Metallfadenlampen (Correspondence. *E. T. Z.*, Nov. 19).
Böhm, R. Die Vorstufen von Metallfadenglühlampen (*Elek. Anz.*, Nov. 12).
Duschnitz, B. Metallische Leuchtfäden und Metallfadenlampen in der Fabrikation und in der Praxis (*Elek. Anz.*, Nov. 8, Nov. 19).
Dykes, A. H. Wiring for 25 volts (*Electrical Engineering*, Oct. 29).
Editorials. The Electric Light Situation (*G. W.*, Nov. 14).
Badly fitting Lampholders (*Electricity*, Nov. 20).
The Incandescent Lamp Situation (*Elec. World*, N.Y., Oct. 31).
The Small Consumer (*Elec. World*, N.Y., Nov. 7).
Eichel, E. Neuerungen der Amerikanischen Beleuchtungstechnik (*Elek. Anz.*, Nov. 22, Nov. 25).
Fasolt, F. Die Steuer auf Leuchtgas und elektrische Energie in Italien (*E. T. Z.*, Nov. 19).
Flesch, M. L. L'Eclairage Electrique (*L'Electricien*, Oct. 31, Nov. 7).
Mylo, R. Die Fernschaltung und Fernüberwachung der offentlichen elektrischen Beleuchtung in Berlin (*E. T. Z.*, Nov. 5).
Schreiber. Installationsmaterial für Beleuchtuug von Bergwerken (*E. T. Z.*, Nov. 5).
The German Tax on Gas and Electricity (*Electrical Engineering*, Nov. 19, *Z. f. B.*, Oct. 30, *E. T. Z.*, Nov. 12).
Progress in Electric Lighting by means of Metallic Filanet Lamps (*Electrician*, Nov. 13).
Illumination of Seventh Avenue, Manhatten Borough, New York (*Elec. World*, N.Y., Nov. 7).
Die neueren Bogenlampen (*Z. f. B.* Oct 30, Nov. 10, Nov. 20).

GAS, OIL, AND ACETYLENE LIGHTING.

Adams, A. D. Village Lighting (*Acetylene*, Nov., from *The Scientific American*).
Elliott, E. L. The Possibilities of Artistic Effects in Gas fixtures (*Illuminating Engineer*, N.Y., Oct.).
Haber, F. Ueber die Bunsenflamme (*Z. f. B.*, Nov. 20).
Humphreys, Dr A. C. Presidential Address, before Am. Gas Institute (*Progressive Age*, Nov. 2).
Litle, T. J. Better Gas Illumination (Paper read at meeting of Am. Gas Institute, Oct., *Am. Gaslight Journal*, Nov. 9).
Schilling, E. Bericht der Kommission für die Gasbeleuchtung von Warenhausen (*J. f. G.*, Oct. 31).
Schumann, Ergebnisse von Beleuchtungsmessungen (*J. f. G.*, Oct. 24).
Thurston Owens, H. The Development of Gas Street-Lighting Fixtures (*Illuminating Engineer*, N.Y., Oct.).
A German Tax on Light (*G. W.*, Oct. 31, Nov. 7, *J. G. L.*, Oct. 27, Nov. 3, Nov. 10, *J. f. G.*, Oct. 24, Oct. 31, Nov. 5, Nov. 14).
The Bamag Distance-lighter (*G. W.*, Nov. 14).
Self-lighting Incandescent Mantles (*G. W.*, Nov. 21).
Gas at the Franco-British Exhibition (*J. G. L.*, Nov. 3).
American Gas Institute. Third Annual Meeting (*J. G. L.*, Nov. 10, Nov. 17).
New Outdoor Lamps (*J. G. L.*, Nov. 17).
Proceedings of the 11th Annual Acetylene Association Convention (*Progressive Age*, Oct 15).
Etude sur le Bec "Intensiv Viseaux" (*Jour. de l'Eclairage de Gaz.*, Nov. 5).
Unveraschter Invertglübstrumpf (*Z. f. B.*, Nov. 10).
Beleuctung mit flüssigen Lenchtmaterialen, &c. (*Z. f. B.*, Nov. 10).

MISCELLANEOUS.

Dryedale, Dr. C. V. Sur le Rendement lumineux et l'Equivalent Mécanique de Lumière (*Jour. de Physique*, Nov., 1908).

Titchener, E. B., and Pye, W. H. On the After Images of subliminally Coloured Stimuli (*Proc. Am. Phil. Soc.*, Vol. XLVII., No. 189, 1908).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. Anz.—*Elektrotechnischer Anzeiger.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

CORRESPONDENCE.

Ultra-Violet Light: Need We Fear its Effect upon the Eye?

(A reply to Dr. Voege's remarks on this subject. See *The Illuminating Engineer*, September, 1908, p. 775.)

BY DR. F. SCHANZ AND DR. K. STOCKHAUSEN.

IT may be pointed out that a valid answer to this query was furnished long ago, and many electrical engineers have experienced sensations that enable them to reply decisively on the question in dispute.

"Electrical ophthalmia" is a perfectly authenticated effect of the arc-light on the eye. Ordinarily we do not expose ourselves to the light in the same way as the engineers referred to above. But is a poison that has been so diluted as to give rise to no acute injurious sensations therefore no poison? That our eyes rapidly become wearied by the light of the arc, and that unpleasant effects on the eye have been recorded, can hardly be denied. Do not these records of injury in themselves suffice?

Recently, however, Prof. Birch-Hirschfeld has recorded injuries to the eyes—for instance, local disturbance of the colour-sense of those working with the mercury lamp—which were not accompanied by the special circumstances characteristic of electrical ophthalmia. He considers, moreover, that these effects, the existence of which is only with difficulty detected, occur anything but infrequently. But are the ultra-violet rays to be considered harmless even supposing that manifestations of their action have only been recorded in the case of the mercury lamp?

Dr. Voege also contends that our eyes are adapted to the use of daylight, and that, therefore, artificial illuminants, which contain a weaker ultra-violet element than daylight does, can hardly be deemed dangerous on this account. Yet his assumption that the ultra-violet rays in daylight are harmless is not well grounded. Even under ordinary conditions the ultra-violet light in daylight can produce reddening and irritation of the skin, and may, in the case of unusually sensitive subjects, give rise to eruptions on the skin somewhat similar to those occurring in small-pox patients. In mountainous districts, where the ultra-violet constituent in daylight is exceptionally powerful, the so-called "glacier-burning" action on the skin is well-known.

These circumstances give rise to corresponding inflammatory conditions in the outer portions of the eyes that are well-known experiences on the part of those accustomed to work outdoors in the fields, &c. Also so-called "spring-catarrh" (*Frühjahrskatarrh*) of the *conjunctiva retina* has been shown by several authors to be, at least, partially due to the accentuation of the ultra-violet constituent in daylight at the beginning of the spring season. In polar regions the effect occurs in its most severe form as "snow-blindness" and "red-vision" (*Erythropsie*). These effects are ascribed to the reflection of strong ultra-violet radiation from the snow.

These considerations alone seem to invalidate Dr. Voege's argument by appeal to daylight-illumination. Moreover, as was urged in the course of the discussion at Erfurt this year (see *The Illuminating Engineer*, October, 1908, p. 855), the proportion of ultra-violet light in daylight is exceedingly variable, and that in all cases the illumination employed was of a diffused character from which almost all the ultra-violet light had been eliminated by successive reflection. Thus in cases in

which the ultra-violet constituent in daylight is known to be exceptionally powerful, we take measures to protect ourselves, and when in the open avoid the exposure to the *direct* radiation of the sun; in cases in which such protection is impossible our eyes suffer.

The best means of protection available is our headgear, which has been so developed as to screen our eyes from the direct rays. When we are, however, obliged to subject ourselves to directly-reflected sunlight, *e.g.*, from snowfields or the surface of water, we have resource to the protection of spectacles. It has been demonstrated that blue glasses which allow ultra-violet rays to pass through them with special ease, are not so serviceable for this purpose as grey ones.

Now, corresponding protection from the *direct rays* is usually wanting in the case of artificial light. Indirect illumination, though preferable from this point of view, has been but little utilized, chiefly from considerations of cost. This distinction between natural and artificial conditions of illumination seems not sufficiently appreciated by Dr. Voege in his comparison of the respective conditions.

Attention must also be paid to another important consideration. What kind of daylight ought to be selected as our standard of comparison with artificial illumination? For this purpose a sky of a certain constant standard intensity should be selected; but what type of sky meets this condition? Dr. Voege himself admits that the blue sky is richer in ultra-violet light, but less bright than a clouded one; and he, like many others before him, records that the ratio of ultra-violet to the visible energy in daylight varies very greatly with the climatic conditions. It is clearly unsatisfactory when attempting to put forward a rigid physical proof to employ a source of comparison that is admittedly so variable. Moreover, optical brightness and photochemical intensity are two quite different factors, and even the ultra violet rays constitute only a fraction of the radiation that affects a photographic plate.

Moreover, according to Dr. Voege's researches the solution of nitrosodimethylaniline, which he employs with the object of eliminating the visible rays, absorbs rays between the limits of 0·5 μ and 0·37 μ, and yet allows light and wave-lengths lying between the H and K lines, and 0·2 μ to pass through unchecked. Yet the H line corresponds with a wave-length 0·4 μ, and the K line with a wavelength of 0·397 μ. According to the complete tabulation due to Listing,* the visible spectrum ends at 0·397 μ, and the normal eye cannot detect rays without assistance. By using the solution referred to above, Dr. Voege cuts out an intense ultra-violet band occurring in the spectrum of the arc-light, and of much greater consequence than the simultaneously absorbed ultra-violet region of the spectrum of daylight.

The comparison of a glow-lamp with the brightness of sunlight reflected from a polished metallic surface, critically regarded, can hardly be seriously endorsed as a basis of comparison.

On the basis of the aforesaid assumptions† Dr. Voege comes to the conclusion that the spectrum of sunlight without the screening effect of glass indeed, even after the light has passed through a sheet of glass, extends further in the ultra-violet than the spectrum of all artificial illuminants.

Yet Cornu‡, even under the favourable circumstances, failed to detect wave-lengths further than 0·295 μ; while Rowland,§ again, placed the limit at 0·300 μ. On the other hand light of wave-lengths as small as 0·2 μ has been proved to exist in the spectrum of the arc-light. And even were our artificial illuminants invariably surrounded with a glass envelope, ultra-violet rays of 0·3 μ to 0·4 μ would be allowed to pass unhindered, only those below 0·3 μ being, in general, absorbed by glass of the ordinary variety.‖

* Listing, *Pogg. Ann.*, 131, 564, 1868.

† *E.T.Z.* 1908, p. 781.

‡ Cornu. *Compt. Rend.*, 1878, p. 102.

§ Rowland, Photographic map of the solar spectrum, J. Hopkins Press, Baltimore, U,S.A.

‖ *E.T.Z.* 1908, p. 778, Spectra 1 and 2 in Fig. 1., *Illuminating Engineer*, Sept. 1908, p. 772.

Dr. Voege would certainly have arrived at the same results had he adequately screened his plate from all stray light, and used a slit 1 to 2 mm. in length as is customary in spectrographic measurements, instead of one mm. long.

Dr. Voege has admitted that spectra of, at least, two existing sources, the Regina arc and the quartz mercury-vapour lamp, contain more ultra-light violet than daylight, and therefore a protecting screen would, in these cases, be necessary. Even supposing, however, that he succeeded in demonstrating, by methods to which no possible objection could be taken, that one surface, illuminated with a certain optical intensity, emitted more ultra-violet rays than another, even this would not decide whether or no the ultra-violet light present in artificial illuminants can be considered harmless.

This is emphatically a question for the physiologist to determine, rather than the illuminating engineer.

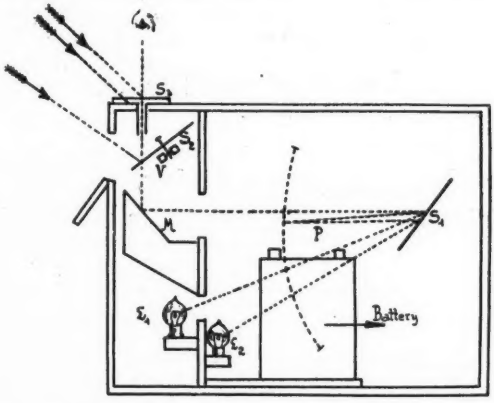
The Improved Harrison Photometer.

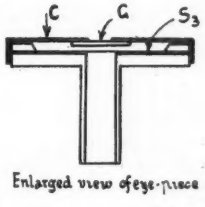
(We have received the following description of an improved form of Harrison Street Photometer, which, through the courtesy of the inventor, we have recently had an opportunity of inspecting. It may be of interest to recall that a description of this instrument has been previously published in *The Illuminating Engineer*, June, 1908, p. 504):—

THIS instrument is intended for measuring illumination on a screen at an angle of 45 degrees from the vertical, and also the candle-power of sources of light. For this purpose a flicker head is used, rotated by an air blast under the control of the operator, thus making it possible to obtain accurate results when measuring illumination derived from light sources of any nature.

of horizontal illumination to be made in the same way as is done in the Trotter Preece photometer, with the exception that the moving or adjustable screen is viewed by means of the mirror, which is used with the flicker head, the sector of which is set and fixed so as not to interrupt the view.

This means of fixing the moving sector also makes it possible to use the





The addition lately made to the instrument consists of a horizontal screen which is covered, when making the measurements above referred to, by a cap having a hole through the centre, forming the eye-piece. This cap when removed exposes a white horizontal screen, thus permitting measurements photometer as a direct comparison instrument, should it not be considered necessary to use the flicker, as the sector can be set in such a position as to be illuminated by the source of light to be measured and to be visible through the eye-piece, at the same time exposing to view the variable angle

screen illuminated by the standard lamp, thus permitting a balance to be made.

It will be seen that any of the following measurements can now be made by means of this instrument :—

1. Candle-power with a flicker head.
2. Candle-power by the direct comparison method.
3. Illumination on screen at an angle of 45 degrees with flicker head.
4. Illumination on screen at an angle of 45 degrees by direct comparison.
5. Horizontal illumination by direct comparison.

The other advantages of this instrument have all been retained in the new model, namely :—

1. Light weight and portability.
2. Long range with two different standards.
3. Permanent connexions between cells and standard lamps, which need never be disconnected.
4. Ease of removal from case of battery, standard lamps, and flicker head for inspection and charging without disconnecting.
5. Easy and accurate manipulation due to method of rotating flicker head.

The figure shown illustrates how these objects are attained and the general simplicity of the apparatus.

Light Tinted Symbols on Dark Backgrounds.

We have received a letter from Mr. A. J. Marshall, of the Bureau of Illuminating Engineering, New York, commenting upon our reference to the above subject in the September number of *The Illuminating Engineer*, p. 778.

Mr. Marshall wishes to point out that what he advocates is the use of *light-tinted* symbols on *dark* grounds, but not necessarily white on black. On the contrary, he considers this combination undesirable, and prefers a yellow tint on a dark-green background, as being restful to the eyes, though his experiments are not yet sufficiently complete to justify this being regarded as the ideal arrangement.

The too sudden adoption of the plan recommended, would admittedly be confusing and possibly injurious to the eyes ; therefore Mr. Marshall advocates that the process of alteration should take place gradually, and that, in the meanwhile, amber-tinted paper with a rough matt surface ought to be used in books, especially those used in school work.

The Absorption of Arc-Lamp Globes.

Dear Sir,—I do not think Mr. Denman Jones has quite appreciated the test I suggested. The method I proposed for determining the absorption of a globe by measuring illumination from an arc-lamp first through the globe and then through a hole in it, is, I believe, quite a good one. These measurements make a comparison between the illumination from the globe, plus that due to the bare arc, with the illumination from the globe plus that due to the arc when it is obscured by the globe. It is obvious that the comparison between these illuminations does not give the absorption of the globe directly. To determine the actual absorption a small portion of the globe close to the hole might be covered with an opaque card, and a third measurement of the illumination (from the globe alone) made on the darkened patch. By subtracting the illumination due to the globe alone from each of the other two the ratio between the light from the arc with the globe to the light from the arc without the globe is at once found. The actual source of light with which the globe has to be used is employed, and all the other conditions to which I referred in my last letter are similar.

The difference in the absorption-coefficent found by Prof. Morris and

myself is, I believe, largely one of definition. When I spoke of absorption I meant the absorption as measured by a comparison between the intensity of a beam of light passing through the globe to the intensity of the same beam had the globe not been there. An average value of the absorption may be found by determining the mean hemispherical candle-power for the two cases. If the absorption is measured as the ratio of the total light in a given direction, with the globe in place, to the light there would otherwise have been, the result is very different. A large proportion of the total light so measured is that scattered from the surface of the globe. The ratio of light absorbed to total light measured in this way can, I think, hardly be called the coefficient of absorption for the globe, though it is coefficient of great practical importance. As an example of the difference between these two quantities I may mention the following test: With a large opal arc-lamp globe tried with a Tantalum lamp, the true absorption of the globe was found to be 82 per cent, while the apparent absorption was 36 per cent.

In determining the total light from a lamp it is, of course, the latter coefficient that is important, and which, no doubt, Prof. Morris measured in the tests I have ventured to criticize.

Yours very truly,

E. W. MARCHANT.

REVIEWS OF BOOKS.

Annuaire International de l'Acetylene.

EDITED BY MM. R. GRANJON AND P. ROSENBERG.

Bibliothèque de l'Office Central de l'Acetylene, 104, *Boulevard de Clichy, Paris*, 2 *francs*.

THE second number of the 'Annuaire International de l'Acétylène' fills nearly 300 pages, which contain a considerable amount of useful information on the production and uses of acetylene, arranged in a concise and readable form.

The eighteen chapters comprised in the volume cover a great variety of subjects, and some of them are of exceptional interest, notably those dealing with acetylene burners, incandescent acetylene lighting, and different applications of acetylene for lighting purposes. Chaps. i. to iv. also contain a summary of methods of generating and purifying the gas, which will doubtless be found useful by those anxious to gain a rapid survey of the technicalities of this subject. The volume, as a whole, undoubtedly achieves its evident object of illustrating the extent of the subject of acetylene lighting at the present day and the other extremely varied directions in which acetylene seems to be finding application.

The last portion of the book contains some useful statistics relating to the development of acetylene in different countries and the existing institutions and societies devoted to the discussion of the subject, followed by the subject-index, and a list of addresses of dealers in carbide and acetylene apparatus in different countries.

Le Nuove Lampade Elettriche ad Incandescenza.

BY G. MANTICA.

Biblioteca dell' Associazione Utenti Energia Ellettrica d'Italia, Via Cernaia, 11, *Milan*.

THIS book contains a general and up-to-date survey of the metallic filament and other incandescent lamps of the present day. The first two chapters are devoted to a historical summary of the subject and some remarks on the incandescent lamps in general, and the third discusses the carbon filament lamp; the Edison, Bernstein, Cruto, and other early lamps are briefly mentioned, and the metallized filament also receiving attention.

The fifth—the most important chapter in the book—contains a more detailed study of the various tungsten lamps, the osram, zircon-wolfram, colloidal, &c., and is illustrated by a number of charts of tests carried out in the photometrical laboratory of the Associazone Utenti Energia Elletrica, to the members of whom this book is dedicated.

Other chapters in the book deal briefly with the problems of radiation underlying incandescent lamps, and the standard specifications applying to their sale in Italy.

PATENT LIST.

PATENTS APPLIED FOR, 1908.

I.—ELECTRIC LIGHTING.

22,003. Anti-vibration device for pendants, &c. Oct. 17. A. Newall, 73, Approach Road, Victoria Park, London.
22,454. Arc lamps. Oct. 22. S. C. Mount and Beck Flame Lamp, Ltd., 27, Chancery Lane, London.
23,053. Fixings for electric fittings. Oct. 29. J. J. Rawlings, 34, High Holborn, London.
23,069. Supports for incandescence filaments (C.S.). Oct. 29. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.) (Addition to 16,531/07.)
23,070. Supply and regulation of electric energy for searchlight arc lamps. Oct. 29. The British Thomson-Houston Co., Ltd., and A. A. Pollock, 83, Cannon Street, London. (Addition to 4,379/05.)
23,726. Filaments for incandescent lamps. Nov. 5. The British Thomson-Houston Co., Ltd., and H. H. Needham, 83, Cannon Street, London.
24,760. Regulating arc lamps for theatres, &c. Nov. 18. H. Powell, 4, Clayton Square, Liverpool.

II.—GAS LIGHTING.

21,887. Lighting and extinguishing. Oct. 16. H. L. Doun and Telephos, Ltd., 115, Cannon Street, London.
21,961. Burners for lighting and heating. Oct. 17. G. Wardle, 60, Lever Street, London.
22,520. Mantle rods. Oct. 23. J. R. Hoyland, 3, Brown Street, Market Street, Manchester.
23,122. Incandescent mantles (C.S.). Oct. 30. L. Severin, 231, Strand, London.
23,315. Mantle preserver for upright burners. Nov. 2. G. A. Walker, 25, Clifford Gardens, Willesden, London.
23,555. Inverted incandescent burner. Nov. 4. B. G. Hutchinson, Falcon Works, Eastgate, Barnsley, Yorks.
23,741. Lighting with compressed gas. Nov. 6. T. D. Kelly, 11, Kitchener Road, Upton Lane, Forest Gate, London.
23,830. Inverted incandescent pressure lamps (C.S.). Nov. 6. M. Graetz, 77, Chancery Lane, London.
23,923. Incandescent mantles. Nov. 9. A. Cruickshank, 18, Burstock, Road, Putney, London.
24,303. Incandescent mantles. Nov. 12. E. Swann, 55, Dollis Park, Church End, Finchley, London.
24,385. Intermittent lights for advertising. Nov. 13. A. T. Gilbert, 16, Dundas Road, Peckham, London.
24,493. Inverted incandescent lamps. Nov. 14. J. Keith and G. Keith, 65, Chancery Lane, London.
24,630. Mantles for inverted incandescent burners. Nov. 16. L. Friedeberger, 323, High Holborn, London.
24,689. Incandescent lighting. Nov. 17. H. Reeser and H. E. Bray, 20, Copthall Avenue, London.
24,793. Automatic igniters and extinguishers (C.S.). Nov. 18. (I.C. June 16, 1908, Germany.) M. W. Bröndun, 345, St. John Street, London. (Addition to 10,715/08.)
24,819. Igniting lamps at a distance. Nov. 18. W. Walsham and E. A. Holloway, 55, Greenford Avenue, Hanwell.
24,849. Controller for lighting and extinguishing (C.S.). Nov. 18. J. M. Tourtel and W. R. Mealing, 33, Cannon Street, London.
24,925. Lighting and extinguishing lamps at a distance (C.S.). Nov. 19. A. Grossmann, 173, Fleet Street, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).

22,004. Control of oil, gas and other lamps. Oct. 17. D. A. Symons, 39, Victoria Street, Westminster.
22,274. Acetylite lamp. Oct. 21. M. E. Eggert, 17, Richmond Road, London.
22,401. Igniting apparatus (for gas or oil lamps) (C.S.). Oct. 22. E. Bérnardy, Sunbridge Chambers, Bradford, Yorks.
22,428. Automatically extinguishing lamps when upset (C.S.). Oct. 22. A. O. Stopes, 306, High Holborn, London.
22,481. Lenses for vehical lamps. Oct. 23. R. Whitehouse, A. E. Mitton, H. Mayhew and L. Nichols, Snow Hill Mills, Birmingham.
22,516. Incandescent vapour lamps. Oct. 23. J. H. Miess, Birkbeck Bank Chambers, London. (D.A. Nov. 22, 1907.)
22,621. Anti-vibration device for pendants (gas or electric). Oct. 24. A. Newall, 73, Approach Road, Victoria Park. London.
22,645. Lamps. Oct. 24. S. O. Cowper-Coles, 4, South Street, Finsbury, London.
22,657. Lamps. Oct. 26. C. E. Baxter, 32. Martineau Street, Birmingham.
22,748. Photometer. Oct. 27. H. Chapman, Ryecroft Villas, Meersbrook Road, Sheffield.
22,814. Illumination of railway stations, signs, name-boards, &c. Oct. 27. W. H. Bagley and F. J. B. Collis, 18, Southampton Buildings. London.
23,243. Lamps. Oct. 31. H. Cole, 77, Colmore Row, Birmingham.
23,456. Electric torches, gaslighters, lamps, &c. Nov. 3. Co-operative Wholesale Soc., Ltd., and J. Clarke, 111, Hatton Garden, London.
23,468. Illuminating and heating. Nov. 3. G. Epstein, 54, Willow Road, Hampstead, London.

23,552. Acetylene lamp. Nov. 4. L. J. Maas, 92, Antrobus Road, Handsworth, Birmingham.
23,710. Acetylene lamps. Nov. 5. H. Lucas and W. H. Egginton, 18, Southampton Buildings, London.
24,246. Controlling devices for lighting systems. Nov. 11. D. Anderson, 18, Southampton Buildings, London.
24,365. Automatic ignition device for oil or spirit incandescent lamps (C.S.). Nov. 12. C. Hannemann, 18, Southampton Buildings, London.
24,677. Oxyhydrogen search lights. Nov. 17. L. Kamm, 27, Powell Street, Goswell Road, London.
24,929. Acetylene lamps. Nov. 19. A. Barnett, 9, Warwick Court, Gray's Inn, London.

COMPLETE SPECIFICATIONS ACCEPTED OR OPEN TO PUBLIC INSPECTION.

I.—ELECTRIC LIGHTING.

20,223. Incandescent filaments. Sept. 10, 1907. Accepted Nov. 18, 1908. "Z" Electric Lamp Syndicate Ltd., 111, Hatton Garden, London.
22,756. Lighting of railway carriages. Oct. 15, 1907. Accepted Oct. 21, 1908. E. M. Preston and A. E. Kennard, 77, Chancery Lane, London.
23,148. Arc Lamps (C.S.). Oct. 19, 1907. Accepted Oct. 21, 1908. Johnson & Phillips, Ltd., and C. F. Tubbs, Birkbank Bank Chambers, London.
23,215. Arc lamp electrodes (C.S.). I.C. Oct. 20, 1906, Germany. Accepted Oct. 28, 1908. Deutsche Beck-Bogenlampen-Ges. m. b. H., 27, Chancery Lane, London.
23,429. Electrodes for arc lamps (C.S.). Oct. 23, 1907. Accepted Oct. 28, 1908. E. R. Grote and The Foster Arc Lamp and Engineering Co., Ltd., 40, Chancery Lane, London.
23,781. Arc lamps (C.S.). I.C. Oct. 26, 1906, Germany. Accepted Nov. 4, 1908. Deutsche Beck-Bogenlampen-Ges. m. b. H., 27, Chancery Lane, London.
23,950. Electroliers. Oct. 30, 1907. Accepted Nov. 4, 1908. G. F. Woods, 4, St. Ann's Square, Manchester.
23,991. Incandescent lamps. Oct. 30, 1907. Accepted Nov. 4, 1908. H. E. Theobald, 52, Chancery Lane, London.
24,343. Signal lamps. Nov. 4, 1907. Accepted Nov. 11, 1908. C. W. Cox and The Edison and Swan United Electric Light Co., Ltd., 34, Castle Street, Liverpool.
25,398. Arc lamps. Nov. 15, 1907. Accepted Oct. 21, 1908. A. Wunderlich and G. A. Hughes, 18, Southampton Buildings, London.
25,815. Incandescent lamps. Nov. 21, 1907. Accepted Nov. 18, 1908. J. H. Collings and H. Hirst, 33, Cannon Street, London.
26,135. Enclosed arc lamps. Nov. 26, 1907. Accepted Nov. 4, 1908. G. W. Farthing and T. K. Steanes, 77, Chancery Lane, London.
26,179. Hollow metal filaments for incandescent lamps. Nov. 26, 1907. Accepted Oct. 28, 1908. F. W. le Tall, 2, Norfolk Street, Strand, London. (From A. Lederer, Austria.)
880. Lamp sockets (C.S.). Jan. 14, 1908. Accepted Oct. 28, 1908. A. J. Boult, 111, Hatton Garden, London. (From Benjamin Electric Manufacturing Co., U.S.A.)
2,103. Incandescent lamps. Jan. 30, 1908. Accepted Nov. 18, 1908. Cutler, Wardle & Co., Ltd., and W. Wardle, 55, Market Street, Manchester.
3,076. Incandescent lamps. Feb. 11. 1908. Accepted Nov. 4, 1908. J. A. Leon, 60, Queen Victoria Street, London.
3,266. Arc lamps. Feb. 13, 1908. Accepted Oct. 21, 1908. Johnson & Phillips, Ltd., and S. Paterson, Birkbeck Bank Chambers, London.
4,608. Holders for electric lamps. Feb. 29, 1908. Accepted Nov. 18, 1908. F. W. Suter, Chancery Lane Station Chambers, London.
5,040. Metallic filaments or rods for incandescent lamps (C.S.). I.C. Nov. 9, 1907, France. F. J. Planchon, 40, Chancery Lane, London,
5,387. Incandescent lamps (C.S.). Mar. 10, 1907. Accepted Oct. 21, 1908. A. G. Bloxam, Birkbeck Bank Chambers, London. (From Siemens and Halske, Akt.-Ges., Germany.)
5,416. Filaments for incandescent lamps. Mar. 10, 1907. Accepted Nov. 18, 1908. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (From General Electric Co., U.S.A.)
8,416. Incandescent filaments (C.S.). I.C. April 26, 1907, Germany. Accepted Nov. 4, 1908. Wolfram-Lampen, Akt.-Ges., 7, Southampton Buildings, London.
9,620. Hand-fed Arc-lamps. May 4, 1908. Accepted Nov. 11, 1908. J. Bonn and A. E. Jones, 97, Oxford Street, London.
10,098. Filament for glow lamps. May 9, 1908. Accepted Nov. 11, 1908. J. W. Ward and R. H. Stevens, 11, Southampton Buildings, London.
11,600. Filaments of Chinese ink for incandescent lamps (C.S.). I.C. Oct. 30, 1907, Germany. Accepted October 28, 1908. K. Rittersberg and H. Rubert, 67, Kuesebeckstrasse, Charlottenburg, Germany.
11,603. Tungsten incandescence filaments (C.S.). I.C. June 8, 1907, Germany. Accepted Oct. 21, 1908, Siemens and Halske Akt.-Ges., Birkbeck Bank Chambers, London. Addition to 16,489/07.
12,644. Arc lamps (C.S.). June 12, 1908. Accepted Nov. 18, 1908. J. O. Girdlestone and C. F. G. Thorkelin, 37, Warwick Road, Ealing.
15,079. Decarbonizing metallic filaments (C.S.). July 16, 1908. Accepted Oct. 28, 1908. H. Aron and A. Geiger, 77, Colmore Row, Birmingham.
15,994. Shade devices (C.S.). July 28, 1908. Accepted Nov. 18, 1908. C. W. Frauenlob, 4, Corporation Street, Manchester.
16,534. Refractory conductors (C.S.). I.C. Aug. 7, 1907, U.S.A. Accepted Oct. 28, 1908. W. D. Coolidge, 83, Cannon Street, London.
17,419. Arc-lamp electrodes (C.S.). I.C. Sept. 3, 1907, U.S.A. Accepted Oct. 21, 1908. G. M. Little, Westinghouse Buildings, Norfolk Street, Strand.

24,211, 24,212. Incandescent filaments (C.S.). I.C. Nov. 12, 1907, France. Soc. Fr. d'Incandescence par le Gaz (Système Auer), 24, Southampton Buildings, London. (Additions to 12,720/08).

II.—GAS LIGHTING.

26,373. Upright incandescent mantles. Nov. 29, 1907. Accepted Nov. 11, 1908. F. H. Mitchell, Corrie-Jones, and A. Millward, trading as Lomax & Co., 41, Corporation Street, Manchester.

27,679. Inverted incandescent burner. Dec. 16, 1907. Accepted Nov. 4, 1908. H. Pullen, 27, Listerhills Road, Bradford.

2,606. Street lamps for incandescent lighting. Feb. 5, 1908. Accepted Nov. 4, 1908. T. Glover, 173, Fleet Street, London.

2,951. Automatic gas governor and street pressure changer (C.S.). I.C. Feb. 9, 1907, U.S.A. Accepted Oct. 21, 1908. A. A. Yankee, 118. Holborn, London.

10,223. Regulating nozzles for inverted incandescent lamps (C.S.). May 11, 1908. Accepted Nov. 18, 1908. M. Graetz, 1, Broad Street Buildings, Liverpool Street, London.

13,204. Burning-off gas mantles (C.S.). I.C. Nov. 8, 1907, Germany. H. Drehschmidt, 77, Chancery Lane, London.

13,852. Incandescent lamps with electric ignition (C.S.). I.C. Dec. 31, 1907, France. Accepted Nov. 11, 1908. M. Delage and P. Woog, 25, Southampton Buildings, London.

15,845. Converting pendant with upright incandescent burner into one with inverted burner (C.S.). I.C. Feb. 11, 1908, Germany. Accepted Nov. 4, 1908. F. Heuer, 19, Holborn Viaduct, London.

III.—MISCELLANEOUS

(including lighting by unspecified means, and inventions of general applicability).)

2,492. Turning on and off gas or electric lamps from a distance (C.S.). Feb. 4, 1908. Accepted Nov. 11, 1908. J. V. Wengelin, 111, Hatton Garden, London.

3,060. Systems for the projection of rays (for searchlights, &c.). Feb. 11, 1908. Accepted Nov. 4, 1908. M. Barr and R. A. Bell, 116, Worple Road, Wimbledon, Surrey.

8,104. Filaments for illuminating and heating (C.S.). April 11, 1908. Accepted Nov. 4. 1908. G. Michaud and E. Delasson, 7, Southampton Buildings, London. (Addition to 4,461/08.)

10,662. Burners of reading lamps (C.S.). May 16, 1908. Accepted Oct. 28, 1908. G. Baker, King Edward Street, Whitland, Carmarthenshire.

11,054. Lenses, glasses, or reflectors for motor and other lamps (C.S.). May 21, 1908. Accepted Oct. 28, 1908. A. R. Cosgrove, 19, Holborn Viaduct, London.

15,746. Long distance lighting (C.S.). I.C. July 25, 1907, Germany. Accepted Nov. 11, 1908. J. Lafitte, 111, Hatton Garden, London.

16,602. Incandescent petroleum lamps (C.S.). I.C. Nov. 8, 1907, Italy. G. Bas, 33, Cannon Street, London.

EXPLANATORY NOTES.

(C.S.) Application accompanied by a Complete Specification.

(I.C.) Date applied for under the International Convention, being the date of application in the country mentioned.

(D.A.) Divided application ; date applied for under Rule 13.

Accepted.— Date of advertisement of acceptance.

In the case of inventions communicated from abroad, the name of the communicator is given after that of the applicant.

Printed copies of accepted Specifications may be obtained at the Patent Office, price 8*d*.

Specifications filed under the International Convention may be inspected at the Patent Office at the expiration of twelve months from the date applied for, whether accepted or not, on payment of the prescribed fee of 1*s*.

N.B.—The titles are abbreviated. This list is not exhaustive, but comprises those Patents which appear to be most closely connected with illumination.

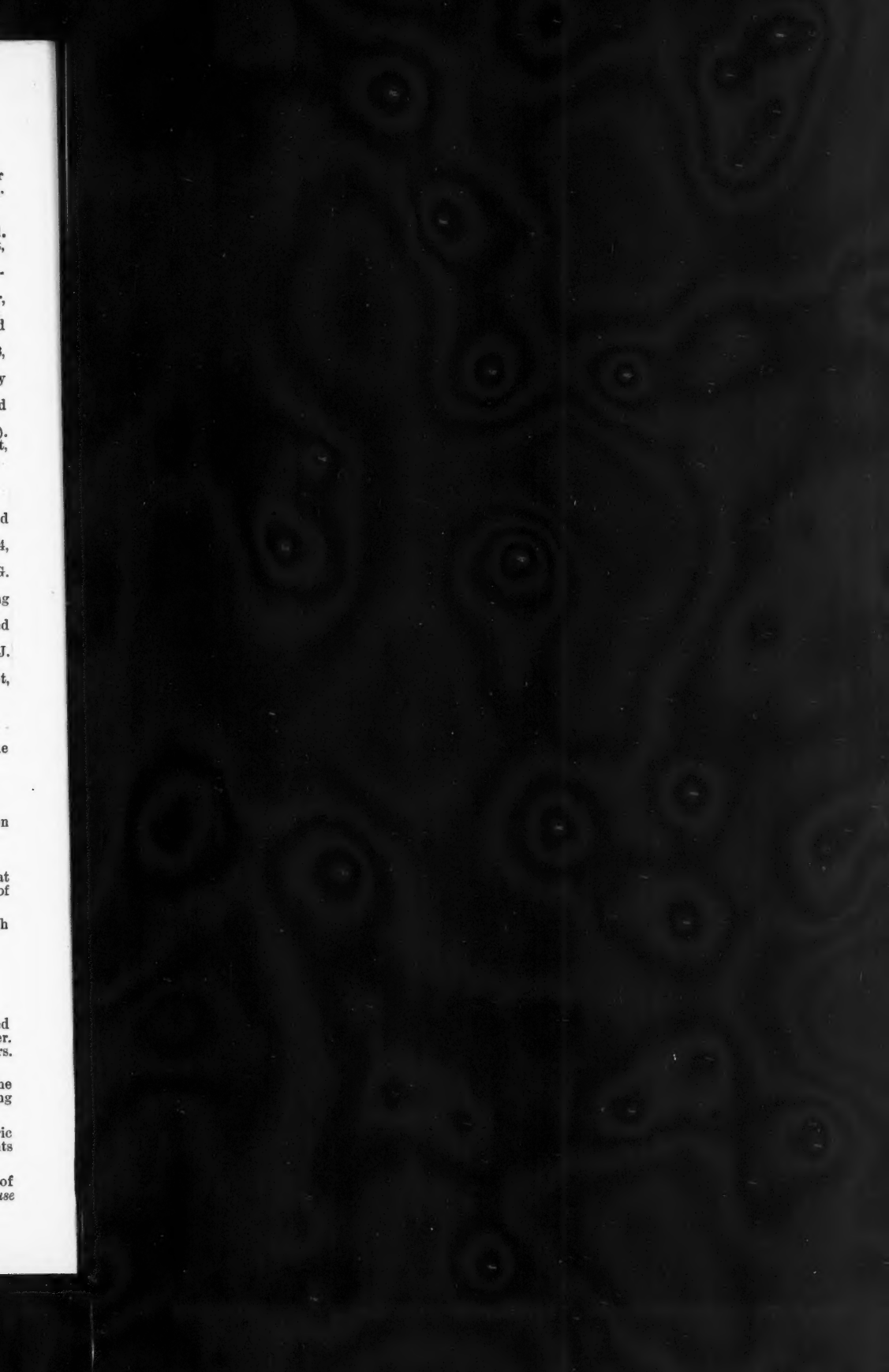
TRADE NOTES.

Messrs. Siemens Bros. draw our attention to the fact that they are now issuing a coloured label in stamp form, which is a reproduction of their well-known "Satisfied Consumer" poster. Perforated sheets of these labels to be obtained by application, enclosing trade card, to Messrs. Siemens Bros. & Co., 6, Bath Street, City Road, E.C.

Messrs. The British Thomson-Houston Co. Ltd., send us an illustrated card descriptive of the B. T.-H. Edison and Tungsten lamps ; also a pamphlet describing the electrical heating and cooking devices by the same firm.

We have also to acknowledge the receipt of the excellently bound and got up 'Verity's Electric Supplies' in three volumes, which constitutes a new departure in catalogues, and presents its contents in an exceptionally complete and handy form.

Among other catalogues of electric, gas, and other fittings received, mention must be made of the publications of *Messrs. The General Electric Co., Ltd.*, and *Messrs. The British Westinghouse Co. Ltd.*, *Messrs. Falk & Stadelman*, *Messrs. Strode & Co.*, and *Messrs. Julius Sax & Co.*





No. I. VOL. I. JANY. 1908

The ILLUMINATING ENGINEER

THE JOURNAL OF SCIENTIFIC

ILLUMINATION

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Among other articles, this number contains :—

A. P. Trotter	Illumination, its Distribution and Measurement ...	7
F. H. Leeds	The Present Status of Acetylene Lighting ...	12
J. A. Flemming	On Vacuum Tube Electric Lighting	19
C. V. Drysdale	The Production and Utilization of Light	27
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W. Grafton	Finality reached in Gas Testing	40
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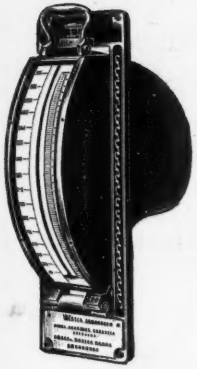
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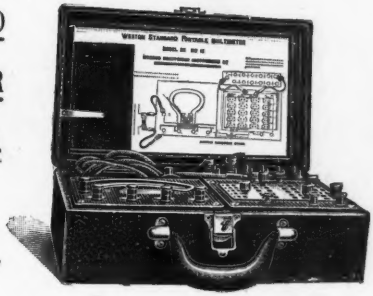
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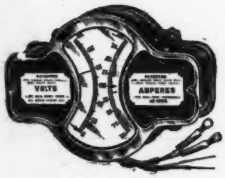
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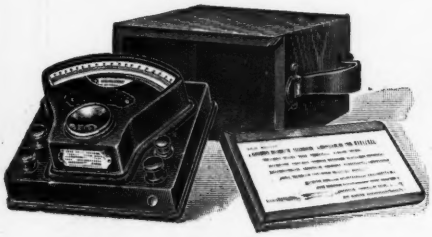
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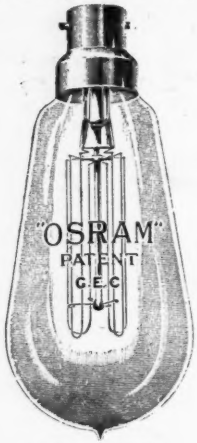
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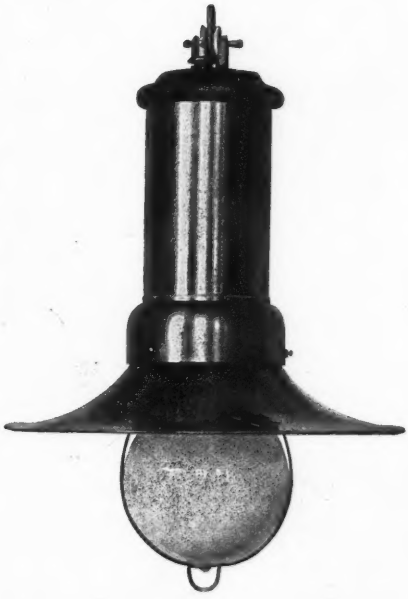
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Water, expelled at 212° Fahr.		·78 p.c.
		100·00 p.c.

PRACTICAL RESULTS.

GASEOUS PRODUCTS.

Gas per ton of coal at 60° Fahr. and 30 in. Bar.	17,560 cub. ft.
Gas from one cub. ft. of the Coal	527·66 „
Spec. Gravity of the Gas	775 (air 1,000)
Hydro-Carbons absorbed by Bromine	22·25 p.c.
Durability of one cub. ft. by 5 in. Jet Flame	87 m. 28 s.
Value of one cub. ft. of Gas in Sperm	1,164·48 grns.
Value of Gas from one ton of Coal in Sperm	2,921·18 lbs.
Illuminating power of Gas in Standard Candles (per union jet consuming 4·47 cub. ft. and calculated to 5 cubic ft.)	48·52 candles
Sulphuretted Hydrogen (H_2S) in foul gas	1·50 p.c.
Carbonic Acid ($C.O_2$) in foul gas	1·33 „
Carbonic Oxide (C.O.) in foul gas	5·75 „
Sulphur eliminated with Volatile Products	11·45 lbs.

LIQUID PRODUCTS.

Tar per ton of Coal	34·50 gals.
Ammoniacal Liquor, per ton of Coal	3·40 „
Strength of Ammoniacal Liquor	5·00° Twadd.
Hygrometric Water, per ton of Coal	1·74 gals.
Aqueous absorbent capacity of Coal (determined by complete Saturation)	1·10 p.c.

SOLID PRODUCTS.

Coke per ton of Coal	725·52 pounds.
Carbon in the Coke	46·40 p.c.
Ash in the Coke	53·60 „
Sulphur in Coke per ton of Coal	2·88 pounds.
Heating Power of one pound of Coke (Water from boiling point into Steam)	6·37 „

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